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CONTENTS

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CORRECTIONS

REVIEW, July, 1928:

Page 273, bottom of 1st column, the denominator of the fraction in the equation should be the Greek lower-case *nu* instead of "v" as printed; next column, equation 7 should be:

$$(7)\quad Cm \doteq \frac{\rho v/\nu}{\tau} = 2.8$$

REVIEW, August, 1928:

Page 334, table near foot of page, in fourth column, second line, "28.8" should be "29.5."

MONTHLY WEATHER REVIEW

Editor, ALFRED J. HENRY

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THE WEST INDIAN HURRICANE OF SEPTEMBER 10–20, 1928

By Charles L. Mitchell

[Weather Bureau, Washington, October 31, 1928]

On the morning of September 10 the S. S. *Commack*, in latitude 17° N., longitude 48° 15′ W., reported a barometer reading of 29.94 inches with wind from the northeast, force 7. This was the first information received relative to one of the greatest hurricanes of record, although this hurricane undoubtedly formed near the Cape Verde Islands. Incidentally this report was received from a vessel about 600 miles east of the longitude of Bridgetown, Barbados, this being the most easterly vessel report concerning a tropical cyclone ever received by radio. At 2 p. m. the same date the S. S. *Clearwater*, in latitude 14° N., longitude 51° W., reported a barometer reading of 29.90 inches with wind from the northwest, force 5, and a pressure fall of 0.10 inch in 2 hours. At 8 p. m. of the same date the S. S. *Clarissa* in latitude 13° N., longitude 51° W., reported a barometer reading of 29.84 inches with wind from the west, force 6. The reports from these three vessels definitely established the fact that a tropical cyclone of unknown intensity was moving almost directly westward, being central at 8 p. m. nearly 600 miles east-northeast of Bridgetown. The following morning a report from the S. S. *Inanda*, in latitude 17° N., longitude 56° W., was received, the barometer reading 29.86 inches with wind from the northeast, force 10. By 8 p. m. pressure had begun to fall in the Lesser Antilles and the wind at Bridgetown, Barbados, had backed from northeast to northwest. The advisory warning issued that evening stated that the center of the tropical disturbance would likely pass over the Lesser Antilles north of Martinique on Wednesday (12th).

At 8 a. m. of the 12th the barometer at Roseau, Dominica, read 29.44 inches and the wind was 24 m. p. h. from the northwest. The path of the hurricane from Dominica to western Ontario, where it merged with an extratropical cyclone on September 20, is shown in Figure 1.

A report received by mail from Pte. á Pitre, Guadeloupe, shows that the center of the hurricane passed close to that place about noon of the 12th with a barometer reading of 27.76 inches (copy of barograph trace in fig. 2). No reports of damage accompanied the barometric data. However, press dispatches from Paris, France, indicate that great destruction was wrought by the hurricane in Guadeloupe, which is a French possession. The English islands of St. Kitts and Montserrat also suffered heavy losses. About 11 a. m. of the 13th the hurricane center passed near the S. S. *Matura*, in latitude 17° 35′ N., longitude 65° 10′ W., a short distance southwest of St. Croix, Virgin Islands, a barograph trace received by mail showing a minimum pressure of about 27.50 inches. A wind velocity of 90 m. p. h. was reported from St. Thomas, 50 miles north of the center, and the island of St. Croix

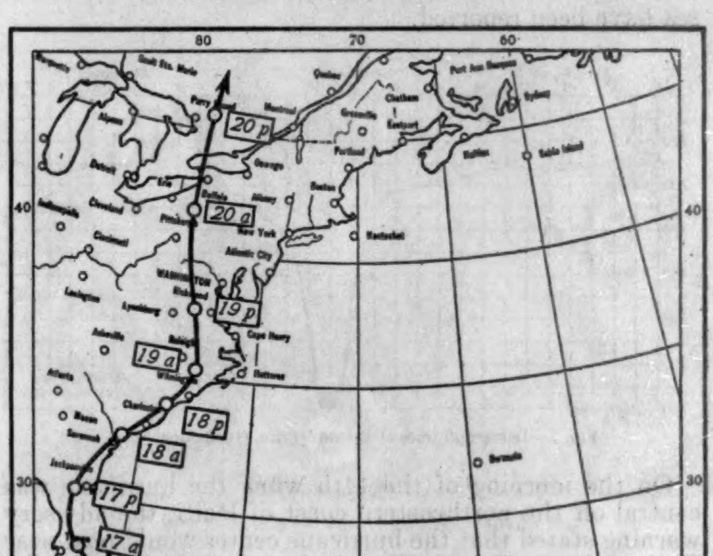


Fig. 1.—Track of hurricane, September 12–20, 1928

suffered heavily in loss of life and in damage to property and crops.

The hurricane crossed Porto Rico during the 13th, causing the loss of many lives and widespread destruction to crops and property. The report of the official in

charge of the Weather Bureau office at San Juan will be found immediately following this article.

After leaving Porto Rico, the direction of movement of the hurricane changed from west-northwest to nearly northwest, maintaining the latter course continuously at a rate of about 14.5 miles per hour until after it passed inland over the east Florida coast near West Palm Beach. There was little damage in the island of Haiti, although the center moved near, and almost parallel to, the northeast coast. This absence of reports of damage is not so remarkable, inasmuch as winds of hurricance force are seldom experienced more than a comparatively few miles to the south and west of the center of a hurricane. This is due to the fact that the pressure gradient is not so steep in these directions, except perhaps for a few miles from the center, as it is to the north and northeast of the center, where an area of high pressure usually lies.

Advisory warnings of the approximate location and direction of movement of the hurricane were issued twice daily beginning with the 11th. Repeatedly, these advisories stated that the storm was a dangerous one and that vessels in and near its path should observe the greatest caution. As a result, few vessels ventured within the danger zone and little damage and little loss of life at sea have been reported.

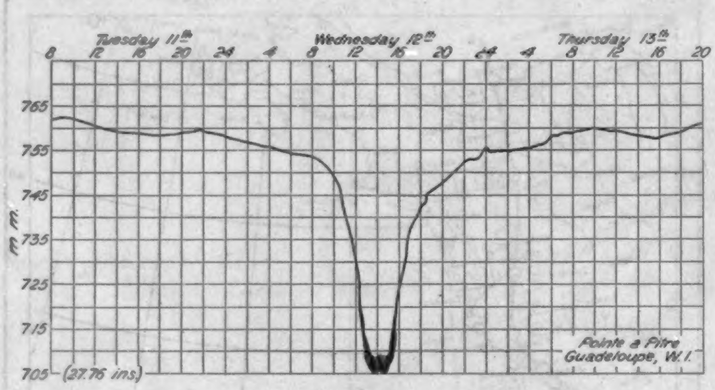


FIG. 2.—Barograph trace at Pointe à Pitre, Guadalupe, W. I.

On the morning of the 14th when the hurricane was central off the northeastern coast of Haiti, the advisory warning stated that the hurricane center would pass near Turks Islands, British West Indies, during the following night. At midnight the barometer at Grand Turk read 28.50 inches and the wind was 120 m. p. h. from the northeast. The following is from a letter received from George S. Frith, of Grand Turk:

Permit me to write and thank you for your very kind advices regarding this and past hurricanes. Without your reports and warnings I do not know, and can not even form the remotest idea, of what would happen to these islands. The hurricane that raged here all Friday night beats all that I know of. The center apparently passed about 9 miles south of our island, which is Grand Turk, and I fear that the Caicos Islands have suffered severely, no reports having been received from there up to the present moment (Sept. 16). No one but those who have passed through one can imagine what it is to witness one of these hurricanes. Two schooners are ashore and a total loss, but with crews saved. They were both consigned to our house and were loading fishery salt for Canadian ports.

The special observer of the Weather Bureau at Grand Turk reports that a sloop, recently built, and on her way to Grand Turk for measurement and registration, was lost, together with 18 lives, at Ambergris Cay.

It was evident the morning of 15th that the hurricane center would pass near Nassau, Sunday (16th) forenoon, and warnings were issued to that effect. Saturday night's advisory read, in part, as follows:

* * * This hurricane is of wide extent and is attended by dangerous and destructive winds. Its center will likely pass near or slightly north of Nassau, Sunday morning. Storm warnings are now displayed from Miami to Titusville, Fla. Winds of hurricane force are probable as far west as longitude 79 degrees (60 miles off the southeast coast of Florida) by Sunday noon. Recurve of hurricane's path not yet indicated.

In addition, the warnings sent to Miami and West Palm Beach stated that "every precaution should be taken (to-night) in case hurricane warnings should be found necessary Sunday on the east Florida coast." A thorough distribution of this information was ordered.

The German steamer *August Leonhardt* en route from New York to Puerto Colombia, was hove to in latitude 23° 10′ N., longitude 74° 10′ W., when the center of the hurricane passed over it about 3 p. m. of the 15th, the lowest barometer reading being 27.80 inches. Just previous to the arrival of the center the wind was north-northeast force 12 (and more). After the barometer had remained stationary and the wind had calmed down for a short time, the hurricane started again at 3:10 p. m., this time blowing from the south-southeast, according to the report of Second Officer R. Sievers, "with an undescribable force. The force of the wind, if more or less, could only be judged by the noise made by the storm, which reminded me of the New York subway going full speed passing switches. Rain and spray were carried away horizontally and our whistle started to blow loudly due to the force of the wind pressing the wire. The foam and spray went up to the masthead (40 meters above the water), this being proved by our antenna and insulators which we had to take down in order to clean off the salt. Hatch tarpaulins, boat ventilators, covers, etc., were torn to pieces and carried away. It is impossible to describe the sea and swell. Spray, rain, and foam was so dense that we could not see our forecastle head."

Continuing in a practically straight course from Porto Rico to Lake Okeechobee, Fla., the center of the hurricane passed near but slightly north of Nassau, Bahamas, on the morning of the 16th. The following excerpt is from the report of Mr. D. Salter, Meteorological Recorder at Nassau:

* * * At 10 p. m. (15th) the corrected barometer reading was 29.50 inches, with overcast sky, and wind northeast 40 miles and freshing rapidly. At midnight the barometer had fallen to 29.35 inches and was still dropping rapidly, overcast sky, and wind northeast 55 miles. At 1:30 a. m. of the 16th the barometer was 29.22 inches, wind northeast 65 miles and increasing, accompanied by rain. Two a. m. saw the barometer down to 29.00 inches and falling every minute, wind still northeast 75 miles, with rain. The 4 a. m. barometer was 28.25 inches, with wind shifting to northwest by west 100 miles. The recording speed register ceased to function at 3:30 a. m., owing to the anemometer cups blowing away while recording 96 miles wind speed. At 5 a. m. the barometer reached its lowest point, 28.08 inches, wind southwest, estimated velocity 110 to 120 m. p. h., and heavy rain. By 6 a. m. the barometer had risen to 28.50 inches and a considerable fall in the wind speed had taken place, although still blowing from the southwest, with heavy gusts, accompanied by rain. * * * The total rainfall during the passing of the disturbance amounted to exactly 9 inches.

* * * Although considerable damage was done to property and to a lesser extent to crops, no loss of life occurred, probably owing to the precaution taken as a result of the numerous early warnings received by wireless telegraphy and made public.

The following warning was issued the morning of the 16th:

Hoist hurricane warnings 10:30 a. m. Miami to Daytona, Fla. * * * No report this morning from Nassau. Indications are that hurricane center will reach the Florida coast near Jupiter early to-night. Emergency. Advise all interests. This hurricane is of wide extent and great severity. Every precaution should be taken against destructive winds and high tides on Florida east coast, especially West Palm Beach to Daytona.

Later in the day storm warnings, which had previously been displayed, were changed to hurricane warnings on the west coast from Punta Rassa to Cedar Keys, and on the 17th north of Cedar Keys to Apalachicola, and north along the east Florida coast as far as Jacksonville.

The center of the hurricane reached the coast in the Palm Beach section about 7:00 p. m. of the 16th. A copy of a barograph trace furnished by the American Telephone and Telegraph Company and which was made in their office at West Palm Beach is reproduced in Figure 3. The corrected sea-level reading is 27.43 inches, 0.18 inch lower than at Miami during the hurricane of September 18, 1926, and is the lowest pressure ever recorded in the United States during a hurricane.

The hurricane moved northwestward over the Florida Peninsula, its center passing over Lake Okeechobee during the early night of the 16th and near and slightly east of Bartow about 7:00 a. m. of the 17th. Its course changed to north-northwest after leaving the Bartow section, and, after passing between Ocala and Cedar Keys it turned toward the north-northeast, passing a short distance west of Jacksonville about 1:00 a. m. of the 18th.

No detailed report of damage along the east Florida coast has been received. The following is the report, in part, of the official in charge of the Weather Bureau office at Miami:

* * * The damage at Miami was negligible, being confined principally to a few plate-glass windows and to awnings. Hollywood and Fort Lauderdale escaped with only slight structural damage to buildings, the most serious losses being from water damage, resulting from broken windows and leaking roofs. A few thousand dollars will cover the losses at both places.

From Pompano north to Jupiter, especially at Delray, Lake Worth, Palm Beach, West Palm Beach, and Kelsey City, there was serious structural and water damage, the losses being greatest at Palm Beach and West Palm Beach. There has been no authentic statement as to the total losses, but they amount to several million dollars.

In the Lake Okeechobee region, the great loss of life and the damage to property were caused by the overflowing of the lake along the southeast shore, principally at Belle Glade, Pahokee, and South Bay. The small houses in those localities were washed away or inundated, and approximately 2,000 persons were drowned. In addition to the immediate losses caused by the storm, practically the entire Everglades region south of Lake Okeechobee has been flooded, making it impossible for growers to prepare the land for the usual early winter crops. This condition represents one of the largest items in the list of losses resulting from the storm.

One of the noteworthy features in connection with the storm was the absence of serious structural damage to substantial buildings. This was also particularly noticeable after the Miami hurricane of September 18, 1926. These two hurricanes, both of major intensity, have shown that buildings properly constructed will not suffer serious structural damage from hurricanes, and that the use of storm shutters will prevent practically any damage to such buildings. This statement applies to frame buildings as well as to those constructed of steel, concrete, brick, or stone.

The hurricane center was of great diameter, the lull attending the passage of the center occurring over a path 25 miles or more in width, while in the Miami hurricane of 1926 the diameter of the center was about 13 miles.

* * * The information that the storm would likely pass inland near Jupiter, moving northwestward (toward Okeechobee) was telephoned to the lake region by this office and by Miami firms having interests along the south shore of the lake. Mr. Frank Schuster, who was located at South Bay, near Belle Glade, visited this office several days after the storm and stated that he had warning in sufficient time to enable him to make many automobile trips in the vicinity of South Bay for the purpose of collecting the white residents and moving them to a large barge. With the assistance of other men, he saved the lives of 211 men, women, and children.

The hurricane apparently reached Lake Okeechobee with little diminution in intensity. Complete barometric and wind data during the storm were furnished by Mr. B. A. Bourne, who is in charge of the breeding work at the Bureau of Plant Industry's sugar cane breeding station located on the shore of Lake Okeechobee about one-half mile northward from Canal Point. The barometer fell rapidly with a corresponding increase in the wind velocity after noon of the 16th. At 5:00 p. m. the barometer was 29.17 inches and the wind 40 m. p. h. from the north; at 7:48 p. m., the barometer was 28.54 inches and the wind 60 m. p. h. from the northwest; and at 8:15 p. m. the anemometer cups blew away after the velocity reached 75 m. p. h. from the northwest, the barometer at this time reading 28.25 inches. By 9:00 p. m. the barometer had fallen to 27.87 inches with an estimated wind velocity of 150 m. p. h. from the northwest. There was a dead calm between 9:30 and 10:00 p. m. when the center passed over the station, the lowest barometer reading being 27.82 inches at 9:45 p. m. Shortly after 10:00 p. m. the barometer began to rise and the wind immediately came with hurricane force from the southeast, reaching an estimated velocity of 160 m. p. h. about 10:45 p. m. The wind force decreased rapidly after 11:00 p. m.

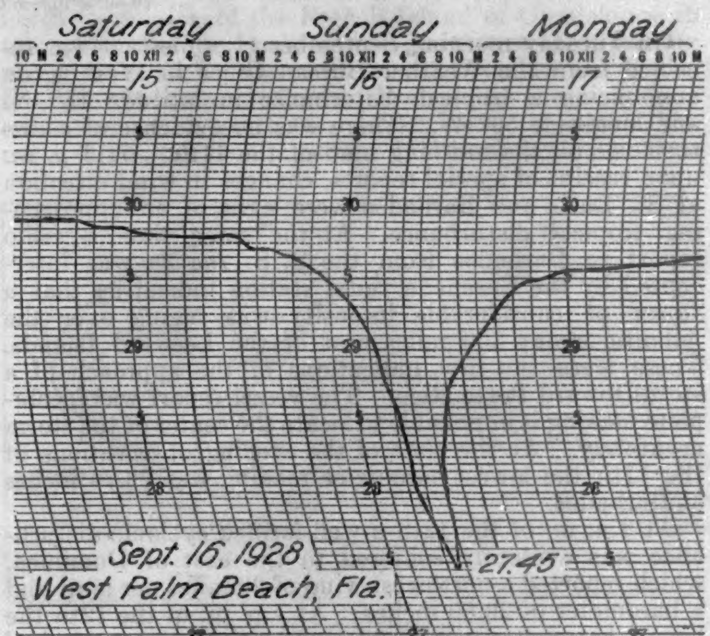


FIG. 3.—Barograph trace at West Palm Beach, Fla.

The following, relative to the progress of the hurricane over Florida, is quoted from the report of the section director of the Weather Bureau at Jacksonville:

* * * Whole gale to hurricane velocities prevailed over the southeast coast and inland from Miami to the south-central and central portions of the peninsula during the night of the 16th, and whole gale to hurricane velocities over much of the interior of the peninsula during the 17th; and gales on the 18th as the storm center moved north-northeastward from the vicinity of Lake, Polk, and Sumter counties near the point of recurve. An appreciable diminution in velocity obtained about the time of recurve, it seems, although sharp, fitful gales, characteristic of hurricanes, featured the storm throughout its course.

A velocity of 100 m. p. h. (or more) seemingly occurred at West Palm Beach, Palm Beach, and Lake Worth. * * * The following velocities occurred at regular Weather Bureau stations: Jacksonville, 48 E. extreme velocity, 56; Miami, 60 W., extreme velocity 78; Key West, 39 W.; Fort Myers, 51 NW., and Tampa, 31 N. Apalachicola and Pensacola were not materially affected by the storm.

The lowest barometer readings at regular stations were as follows: Jacksonville, 28.90; Miami, 28.97; Tampa, 28.98; Fort Myers, 29.14, and Key West, 29.48 inches. The lowest unofficial reading reported north of Lake Okeechobee was 28.54 inches at Bartow.

* * * After September 10, twice daily, warnings were received culminating in the display of hurricane warnings on both coasts. All warnings were correct and timely, and their distribu-

tion effective and valuable. The history of this hurricane is a melancholy one, associated as it is with the tragic ending of nearly 2,000 lives on Lake Okeechobee, whose waters attained a height of 10 to 15 feet as they were forced southward and impinged on the shallow rim of the lake. The damage to property, greatest at Lake Worth and the beaches, approximated millions. The total property loss at West Palm Beach, Palm Beach, and other places in Florida affected and relieved by the Red Cross is given as $25,000,000, which seems high.

On October 28 Red Cross officials announced their official casualty estimate, placing the number of dead at 1,836, and of injured at 1,870 for the entire storm area in Florida. The detailed casualty list is as follows: West Palm Beach area (from Jupiter to Delray Beach), 26 dead, 1,437 injured; Broward County, one dead, 51 injured; Palm Beach County, 1,700 dead, 265 injured; Okeechobee County, 25 dead, none injured; other territory, 84 dead, 67 injured. A total of 10,172 families had registered with the Red Cross applying for aid up to October 28, about two-thirds of this number being in Palm Beach County.

After leaving Florida the storm decreased steadily in intensity as it moved close to the Georgia and South Carolina coasts and passed into North Carolina the night of the 18th–19th. On the 19th its course again changed to north and later toward the north-northwest, diminishing greatly in intensity and merging with another disturbance over Ontario during the 20th. No material damage has been reported from the Coast States north of Florida.

SAN FELIPE [1]—THE HURRICANE OF SEPTEMBER 13, 1928, AT SAN JUAN, P. R.

By OLIVER L. FASSIG, IN CHARGE

[Weather Bureau Office, San Juan, P. R.]

On Tuesday morning, September 11, a message was received from the Weather Bureau Office in Washington announcing a tropical disturbance in latitude 15° N. and longitude 50° W. There was no evidence of a disturbance on the morning map of the 11th. At 3 p. m. upon receipt of special reports, changes in wind direction at St. Lucia and Barbados were signs of an approaching tropical disturbance. At the same time a radio report to Barbados from the S. S. *Inanda* was intercepted by the Ensenada radio station indicating that a storm of considerable intensity was raging over the Atlantic about 300 miles east of the Leeward Islands. These were the first indications of the approach of a storm toward Porto Rico. The vessel report was incomplete making it impossible to locate the center of the storm accurately. At the time of the evening observations of the 11th the lowest barometer reading was 29.76 inches at Barbados.

At 8 a. m. of the 12th a well-formed cyclonic disturbance was evidently centered to the east of Dominica, which reported a northwest wind of 20 miles per hour and a barometer of 29.50 inches. At 1 p. m. of the 12th the lowest barometer was 29.32 inches with a west wind of 40 miles per hour, at Dominica.

As September storms usually move in a west-northwest direction at an average speed of 12 to 13 miles per hour, the San Juan radio broadcast of Tuesday evening stated that the storm would move west-northwest and that the center would probably pass south of the Island of Porto Rico Wednesday night or Thursday morning. This information was broadcast from the naval radio station at San Juan every 2 hours from 8 p. m. Tuesday night. The warning was telegraphed to the 75 police districts of Porto Rico and otherwise given general distribution over the island. Observations from the Lesser Antilles on Wednesday morning still indicated that the vortex of the storm would pass at some distance south of Porto Rico. Information contained in the 6 p. m. observations of Wednesday the 12th indicated that the storm was centered farther northward than was anticipated and that the center would probably pass directly over the Virgin Islands and Porto Rico. This information was given prompt distribution throughout the island. At the same time hurricane warnings were ordered up at St. Thomas and at 12 ports along the coast of Porto Rico.

The storm broke over the southeastern portion of the Island early Thursday morning with the center near Guayama and passed across the island in a west-northwest direction, leaving between Aguadilla and Isabela. The storm center moved across the island in about 8 hours at the rate of 13 miles per hour. The barometer, as the center passed to the south of San Juan at 2:30 p. m., registered the very low reading of 28.75 inches (28.81 inches reduced to sea-level). (See fig. 1). At Humacao on the east coast of Porto Rico a reading of 28.04 inches was recorded at 1:50 p. m. Ponce reported 28.27 inches at 4:30 p. m.; Arecibo on the north coast 28.75 inches at 3:30 p. m.; Isabela on the northwest coast 27.80 inches at 9 p. m.; Mayaguez on the west coast 28.60 inches at 8 p. m. Guayama on the southeast coast reported the lowest barometer (27.50 inches) at 2.30 p. m. (27.65 inches reduced to sea-level). Guayama, Cayey, and Aibonito reported a period of calm or light winds lasting 20 to 30 minutes, indicating that the storm center passed over these towns.

The steamship *Matura* of the Trinidad Line reported a barometer of 27.50 inches (sea-level) about 10 miles south of the island of St. Croix. As a reading of 27.72 inches was reported at West Palm Beach, Fla., it would seem that the intensity of the storm remained about the same from the Lesser Antilles to Florida—a distance of about 1,700 miles. The storm center apparently kept its initial course west-northwest until it reached Florida, with an average progressive movement of 13 miles per hour, when the path turned to the northwest over Florida, then northward and northeastward across New York State on the 20th.

Rainfall.—The rainfall of the 13th and 14th was the heaviest ever recorded in Porto Rico during the past 30 years. Unfortunately reports from the special observers of the Weather Bureau showed a high percentage of overturned rain gages. In addition, the great velocity of the winds made it impossible to register more than 50 to 75 per cent of the amounts which actually fell. Along the coast the rainfall was generally below 10 inches. In the regions of greatest normal rainfall—the vicinity of Adjuntas in the Central Cordillera and in the Luquillo Mountains the amounts exceeded 25 inches. The approximate distribution of rainfall is shown in Figure 3. Adjuntas, in the central mountain region, reported the phenomenal fall of 29.60 inches, a record which will have to be examined more carefully before being finally accepted. At San Juan the rain gage was overturned before the height of the storm was reached and probably only 50 per cent of the total amount which fell was recorded. It is estimated that the amount should be approximately 10 inches.

[1] It is customary in Porto Rico to name a hurricane after the particular saint's day on which it happens to occur.—*Editor.*

Winds.—At 11:44 a. m. of the 13th the anemometer at the office of the United States Weather Bureau in San Juan lost one of its cups—just after recording a maximum velocity (the greatest velocity in 5 minutes) of 150 miles per hour, and an extreme velocity (the highest velocity in 1 minute) of 160 miles. These velocities probably exceed all official records of the Weather Bureau for similar storms. San Juan was about 30 miles from the storm center when these velocities were recorded. Estimates of 200 miles per hour near the center of the storm appear to be not much overdrawn. At San Juan the storm increased in intensity for 3 hours after the record of 150 miles was made. Most of the damage to property on the Weather Bureau Reservation occurred

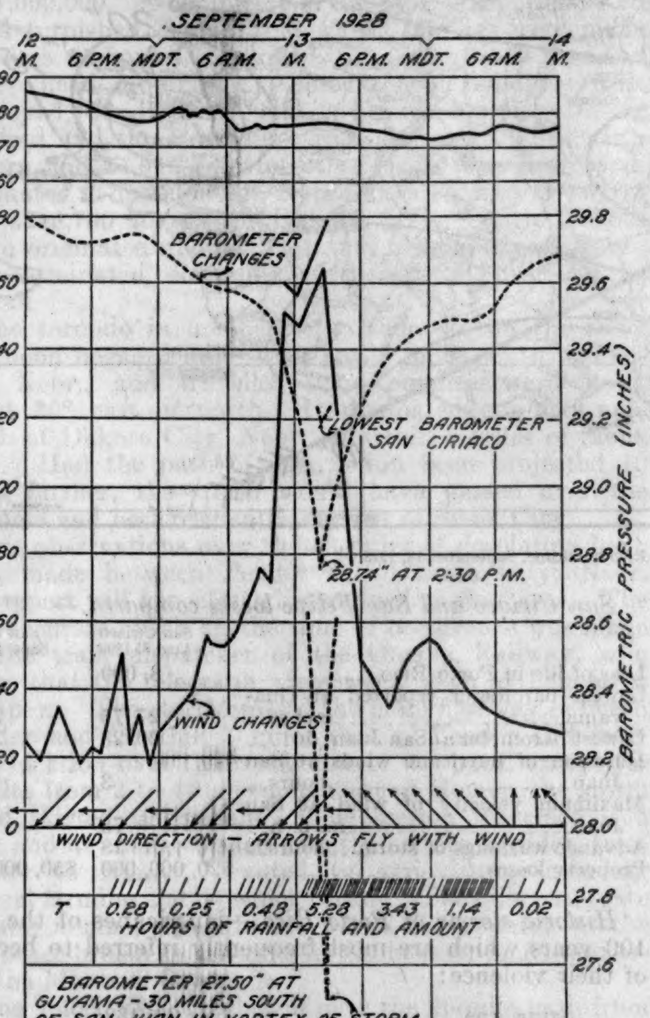


FIG. 1.—Weather elements at San Juan, P. R., hurricane of September 13, 1928

between 2:30 and 3:30 p. m. The balloon shed collapsed at 2:30 p. m. The residence of the official in charge began to lose portions of the roof about the same time and the entire roof and the ceilings were carried away by 3:30 p. m. With only two cups the anemometer still recorded about 75 miles per hour. The second cup disappeared at 12:47 p. m. The arms and the shaft of the anemometer with one cup still attached were blown away at 1:33 p. m.; these parts were later found at San Antonio docks, a distance of a third of a mile to the southwest of the weather bureau wind tower.

The nearest approach to the intensity of San Felipe was San Ciriaco on the 8th of August, 1899. The paths of these two storms across Porto Rico were almost identical. The highest velocity of the wind recorded at San Juan during San Ciriaco was 75 miles per hour on a 4-cup anemometer. The 3-cup anemometer in service at San Juan during the recent storm registers 30 per cent less than the 4-cup variety at velocities in excess of 100 miles. In other words, the 4-cup anemometer formerly used at Weather Bureau stations would have registered not less than 190 miles at San Juan on the 13th at the time the anemometer lost 1 cup.

During the storm of San Ciriaco on August 8th, 1899, it was estimated that fully 3,000 lives were lost during the progress of the storm across the Island of Porto Rico. Most of these fatalities were caused by floods. Loss of life during the recent storm of San Felipe will not exceed 300, due mostly to the fact that the approach of the storm was announced in time to take necessary precautions against loss of life. The lowest barometer reading recorded in 1899 was 27.75 inches at Guayama. The lowest recorded during the recent storm was 27.65 inches at Guayama. The center of the storm passed over the northern portion of the French Island of Guadeloupe in the Lesser Antilles—moved west-northwestward, passing about 10 miles to the south of St. Croix in the Virgin Islands. It entered Porto Rico along the southeast coast and left it on the northwest coast—passed to the north of Santo Domingo and Haiti—doing very little

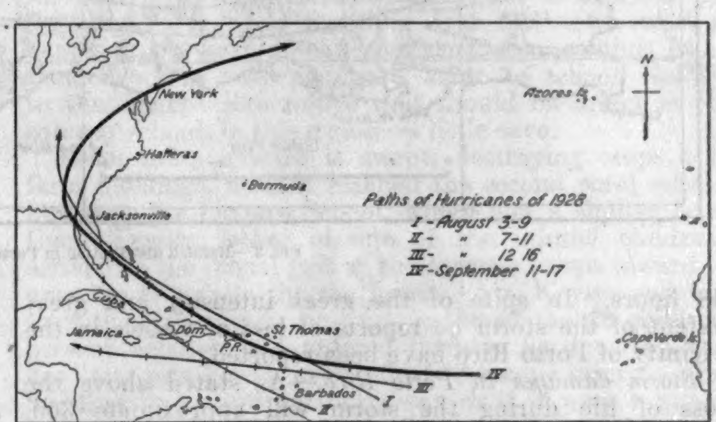


FIG. 2.—Path of hurricanes of 1928

damage in these islands; passed to the south of Turks Islands and Nassau in the Bahamas and entered Florida at West Palm Beach on the morning of the 16th. The French island of Guadeloupe reported heavy loss of life and great property damage. The English islands of St. Kitts and Montserrat, a short distance to the north of the path of the storm also suffered heavy losses. The lowest barometer at St. Thomas, Virgin Islands, 50 miles north of the path, was 29.30 inches, with a maximum wind velocity of 90 miles per hour at 10 a. m. of the 13th. The Island of St. Croix, Virgin Islands, within 10 miles of the center, suffered heavily in loss of life and damage to property and crops.

Area of winds of hurricane force.—Guayama, on the southeast coast of Porto Rico, was in the vortex of the storm at 2:30 p. m. of the 13th. Winds of hurricane force prevailed from 4 a. m. to 10 p. m., a period of 18 hours—assuming a progressive movement of 13 miles per hour for the storm, the area of winds of hurricane force east and west, would be 234 miles. At San Juan, 30 miles to the north of the vortex, hurricane winds prevailed from 4 a. m. to 4 p. m., or 12 hours.

Winds of hurricane force were experienced throughout the island to the north of the path; to the south some portions of the coast were apparently free from hurricane winds. The north-south extent of hurricane winds is

a matter of conjecture in the absence of vessel reports either to the north or south of Porto Rico during the storm. A fact worthy of notice is that few vessel reports were received at any time during the progress of the storm, indicating that timely warnings held vessels in port or kept them away from the zone of danger. In San Juan harbor several vessels delayed sailing for 24 to 48 hours. In spite of the great intensity and great extent of the storm no reports of loss of vessels in the vicinity of Porto Rico have been reported.

Storm damages in Porto Rico.—As stated above the loss of life during the storm will approximate 300. Several hundred thousand people were rendered homeless. Some towns near the center of the storm were practically leveled. The principal crops of the island are sugar, tobacco, coffee, and citrus fruits. Sugar and tobacco interests lost heavily but are generally controlled by large corporations able to take care of themselves. The heaviest property losses were sustained by the coffee growers who had in sight one of the largest and best crops in recent years. In addition to the loss of the crop the shade trees, requiring years to replace, were largely destroyed. The citrus fruit growers lost their entire crop but most of the trees were saved. Property and crop losses are estimated at approximately $50,000,000.

Storms of 1928.—The storm of September 13th was the fourth to pass across the West Indies during the present hurricane season. All of these came into view to the eastward of the Windward Islands. Three of them struck Florida, inflicting a heavy toll of life and great property losses. Reports of the wreckage of the storm of September 13th (San Felipe) will probably confirm statements made that it was the most destructive storm on record in the West Indies. The extremely low readings of the barometer (27.50 inches) and the unparalleled intensity of the winds experienced will substantiate the claims.

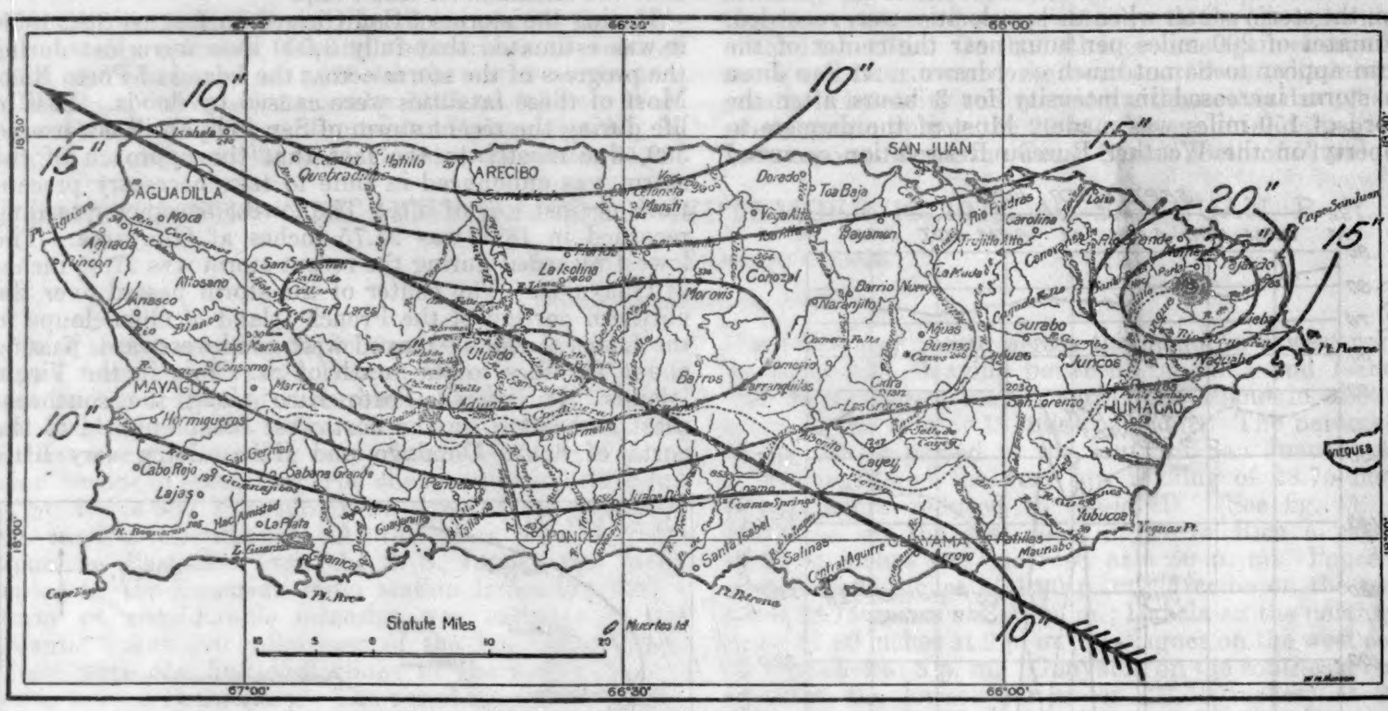


FIG. 3.—Rainfall distribution in Porto Rico hurricane, September 13, 1928

San Ciriaco and San Felipe losses compared.—

	San Ciriaco Aug. 8, 1899	San Felipe Sept. 13, 1928
Loss of life in Porto Rico	3,000	300
Lowest barometer reported at Guayama, inches	27.75	27.65
Lowest barometer at San Juan, do	29.23	28.81
Duration of hurricane winds at San Juan, hours	3	12
Maximum velocity of wind at San Juan, m. p. h.	75	+150
Advance warnings of storm, hours	[1] 18	36
Property losses	$20,000,000	$50,000,000

Historic storms of Porto Rico.—Hurricanes of the past 100 years which are most frequently referred to because of their violence:

Santa Ana	July 26, 1825.
Los Angeles	August 2, 1837.
Santa Elena	August 18, 1851.
San Narciso	October 29, 1867.
San Felipe (I)	September 13, 1876.
San Ciriaco	August 8, 1899.
The 2nd San Felipe	September 13, 1928.

[1] Owing to lack of facilities for prompt distribution of the warning to the rural population, the storm struck them unannounced.

THE MIDDLE MISSOURI VALLEY TORNADOES, SEPTEMBER 13, 1928

By G. K. GREENING, Jr.

[Weather Bureau, Sioux City, Iowa]

On the afternoon of September 13, 1928, a series of tornadoes—four in all—developed within a radius of 80 miles of Sioux City, Iowa, in southeastern South Dakota, northeastern Nebraska and northwestern Iowa. The Iowa storms visited Ireton, 40 miles north and Fonda, 80 miles east of Sioux City. Both of these were relatively of minor development and the damage was largely local in area. The other two, violent and destructive, claimed a toll of eight lives and property damage slightly in excess of $1,000,000. A complete survey by the American Red Cross furnished herewith shows 51 families were made homeless, 87 horses were killed, 136 cattle, 1,619 hogs and 11,690 head of poultry. Three school buildings were destroyed, 66 dwellings and 264 farm buildings. One hundred and three dwellings were damaged, 5,914 acres of corn and 24,641 acres of other crops were destroyed. Estimates of loss for the Nebraska area were $765,815 and $246,700 for South Dakota. The South Dakota storm originated about 3:15 p. m., near Fordyce, Nebr., and terminated 45 miles northeastward near Davis, S. Dak.

The tornado in northeastern Nebraska on the same afternoon began 2 miles west and 5 miles south of Pender, Nebr., and travelled in a northeastward path, about 30° east of north. It dissipated one-half mile north of Dakota City, Nebr. or within 5 miles of Sioux City. Had the path of destruction been projected 10 miles farther, the storm would have passed over the business and best residential section of Sioux City.

Eye observations over the 33 miles of desolation have been made between Pender and Dakota City, Nebr. The report will henceforth be confined to that area. The first accurate check on the time of occurrence was made by the train dispatcher of the Omaha Railway, who states that the telegraph wires went down at Pender at 3:50 p. m. The storm crossed the main highway between Pender and Walthill 3 miles east of Pender and from that location over the remainder of the path, except for 2 miles from 2 to 4 miles northeast of Homer, the storm cloud skirted the ground. The section traversed is a hilly and at times wooded country on the hillsides, from Pender to Homer, devoted to agriculture, including general farming and livestock raising. The hills terminate 2 miles northeast of Homer where the country to the northeast broadens out into fertile bottom lands bordering the Missouri River.

The velocity of translation over the 26-mile path from the time the storm crossed the Omaha Railway southeast of Pender at 3:50 p. m. till it broke up near Dakota City at 4:30 p. m. was approximately 40 miles an hour.

Coming, as it did, very late in the season, with the corn crop nearly matured and livestock at more advanced growth than in the spring, the damage was much greater than had the storm occurred several months earlier. With much of the area planted to corn and considerable timber along the slopes and over the hillsides, the path is easily discerned. Hail storms occasionally riddle fields of corn in this territory to a sickening degree, but it remains for a tornado to reduce a corn field to nothingness. The corn, where struck, was husked, shredded, and leveled to the ground, a total loss at one blow. A few rods away, the corn stands upright and ready for harvest, a striking contrast as to how nature can frown or smile on neighboring farmers.

The lay of the débris and timbers was easily noted. Most of the corn was flattened to the north, or somewhat to the left of the storm path and uprooted trees lay at right angles in many instances. The wrath of the storm seemed to vent itself on the abrupt north slopes, where best sheltered from high southwest winds. The terrific suction as the funnel swoops over the hillside must account for the abnormal force that draws everything toward it.

Most appalling of all that was laid waste were three rural schools that were in the direct path of the storm, two of which were well sheltered by high hills to the southwest. The first to be struck, the James School, 3 miles east of Pender, was more in the open, with slight rises both to the north and south. A farmer lad, Dale Larson, on sighting the storm, hurried to the schoolhouse and assisted the teacher, Miss Dorothy Smith, in rushing the 29 pupils into a storm cave alongside the building. About two minutes later the tornado struck and the pump at the well and a swing device set in concrete alone survived. No trace of the building was to be seen. A few days later while traveling over the storm area, a happy truck load of children were seen coming from Pender, where they had been taken to school, thanks to that inexpensive refuge that should be found at all country schools in this region—a little cave.

Seven miles onward it swept, destroying crops and farm buildings, until it reached the second rural school building, the Lamare School, which met a similar fate. Gene Keyser, father of one of the injured children, arrived at the school just as the tornado swept toward it over the hills from the southwest. Mr. Keyser and the teacher, Miss Phyllis Stewart, gathered the 23 children present together and ordered them to lie down on the floor and join hands, in an effort to escape injury. The building was swept entirely away as if it were a paper box and two children, Mary Belt and Kenneth Norris, were killed. The teacher was seriously injured.

Six miles to the northeast of the Lamere School, where 2 sets of farm buildings were totally destroyed, 11 persons found refuge in a cave. Freakish incidents, which were plentiful over the whole area, were especially noted at this place. A 1¼-inch cottonwood limb was driven into a 9-inch cement entrance of the same cave and straw was driven fully three-eighths of an inch into hedge posts in the neighborhood. The survivors who escaped injury in the cave gave various descriptions of the sensation felt, one of which was that the sensation "was like a person experiences when taking ether."

Two miles north from this point the third schoolhouse—the O'Connor rural school—met the same sad fate. The building was perfectly sheltered by the hills to the south. At the first signal of the approaching black clouds, Alva Traske, a farmer living near by hopped into his automobile and rushed to the school. En route he lost a tire and arriving at the school he loaded the school children into the car and urged the teacher, Miss Helen Rooney to go along. She declined and her lifeless body was discovered 100 yards west of where the school building had stood, with the door knob in her hand.

The storm moved out into the open country for about 2 miles after passing the O'Connor school and then left the ground for about the same distance, when it descended and left a well-marked trail until it reached Dakota City,

the county seat of Dakota County, where considerable property damage was done. The tornado dissipated about 4:30 p. m. one-half mile north of Dakota City, after having traversed a path of 33 miles across north-central Cuming County, diagonally across central Thurston and the eastern border of Dakota County, Nebr.

The path averaged from a few rods to three-fourths of a mile in width. Except for a distance of about 2 miles the funnel-shaped cloud, which was seen by reliable people over the whole course, never left the ground. Hail, not heavy, but large stones, fell with rain preceding the storm. The sky cleared rapidly after the passage of the tornado and a few observers reported that no rain fell at the time the storm struck. The cloud as a rule, was described as being jet black, with the usual grinding noise heard, timbers, straw, and débris being scattered by the whirling mass. Although the storm dissipated 5 miles southwest of Sioux City, straw, corn stalks, and leaves that had been hurled into the air were scattered over the city between 4:30 and 5 p. m.

Since the occurrence of this tornado, much has been said about a supposed old Indian legend to the effect that Sioux City is safe from tornadoes due to the convergence of three rivers—namely, the Big Sioux, the Floyd, and the Missouri. Previous disasters from the same cause do not warrant faith in such a fallacy, although many firm believers point to the dissipation of this storm within 5 miles of the Missouri River to prove their contentions. This writer has been commended by insurance writers in an article appearing in the daily press for holding such a theory as improbable.

Conforming to the general rule, the Pender tornado formed in the southeastern quadrant of a general cyclonic disturbance. It originated approximately 275 miles to the southeast of the main center. So far as known the only photograph of the storm was taken near Pender, a copy of which is inclosed. Witnesses in that section stated that the funnel when it first formed was made up of several sections, reaching upward from the ground to the main storm cloud, from which small jets of white cloud having the appearance of steam were emitted at intervals. As the cloud lowered the different sections merged into a whirling mass.

The maximum temperature chart for the afternoon of September 13 showed a sharp temperature gradient over the middle Great Plains States, ranging from 96° at Concordia, in north-central Kansas, to 52° at Cheyenne in southeastern Wyoming. The direct cause perhaps was due to the underrunning of the cold currents from the high barometric pressure area that was approaching the middle Rocky Mountain region. The air was very oppressive immediately before the storm struck, as evidenced by noon humidity readings of 72 per cent at Sioux City and 82 per cent at Yankton.

A number of eyewitnesses saw the cloud that wrought havoc dissipate. Mr. E. L. Vannard, secretary of the Morningside Country Club, who with two others was watching the storm from the clubhouse located in the southeastern portion of Sioux City, states that a tree of moderate proportions dropped from the sky within a few feet from where they were standing and that a bundle of oats fell on the golf course. He saw a well-defined black funnel cloud approaching from the southwest, when suddenly it became disconnected and the upper portion seemed to draw up in the clouds while the lower section became disjointed and quickly faded out and disappeared on the ground.

The storm reached Sioux City in the form of a thunderstorm from the south, first heard at 3:56 p. m. and last heard at 4:59 p. m. Rain fell from 3:48 p. m. to 4:50 p. m., amounting to 0.99 inch. A trace of hail was recorded from 4:16 to 4:25 p. m. The maximum velocity of the wind for a 5-minute period was 30 miles from the southeast beginning at 4:31 p. m., with an extreme velocity of 46 miles. The barometer fell gradually from 7 a. m. till 3 p. m. and then quite abruptly till 4:25 p. m., when it reached a sea-level reading of 29.50 inches, the lowest recorded. Then there was a sharp rise making a graph similar to the passage of a thunderstorm.

Summary of damage furnished by the courtesy of American Red Cross

	Nebraska		South Dakota		Combined	
	Number	Value	Number	Value	Number	Value
Dead	4		4		8	
Injured	52		9		61	
Families homeless	51				51	
Families registered	153		20		173	
Number of individuals	846		97		943	
Livestock killed:						
Horses	86	$4,300	1	$50	87	$4,350
Cattle	126	12,600	10	1,000	136	13,600
Hogs	1,280	19,200	339	5,085	1,619	24,285
Poultry	9,525	9,525	2,165	2,165	11,690	11,690
Schools destroyed	3	7,000			3	7,000
Dwellings destroyed	41	102,500	25	62,500	66	165,000
Dwellings damaged	67	67,000	36	36,000	103	103,000
Business houses destroyed			27	67,500	27	67,500
Farm buildings destroyed	222	111,100	42	22,100	264	133,200
Farm buildings damaged	237	47,400	46	9,200	283	56,600
Farm implement sets destroyed	72	36,000	14	7,000	86	43,000
Farm implement sets damaged	77	15,400	16	3,200	93	18,600
Acres corn destroyed	5,399	107,980	515	10,300	5,914	118,280
Acres other crops destroyed	22,581	225,810	2,060	20,600	24,641	246,410
Total		765,815		246,700		1,012,515

THE ROCKFORD, ILL., TORNADO, SEPTEMBER 14, 1928

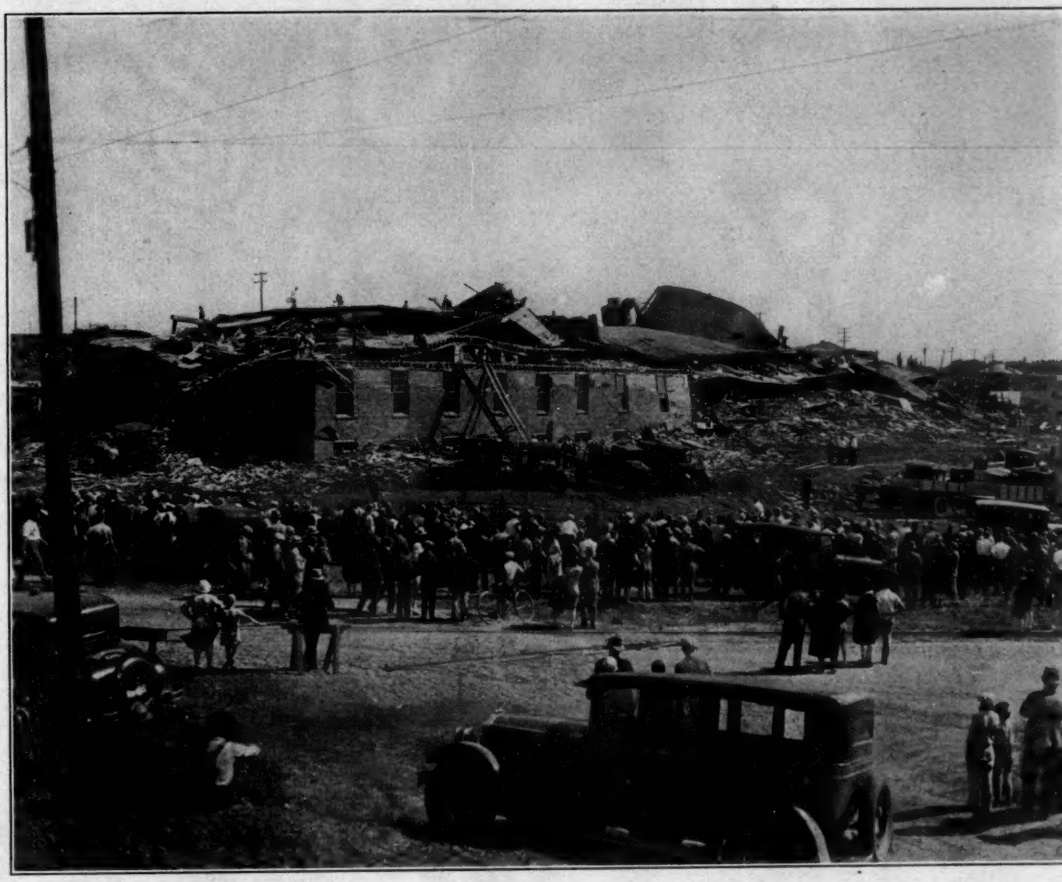
By FRED H. WECK, Assist. Meteorologist

[Cicero Aviation Field, Chicago, Ill.]

The Rockford tornado originated in an area of low pressure which covered the Northern Plains States on Thursday, September 13, and was central over central Minnesota on the morning of September 14. On the afternoon of the 14th, the day of the storm, special reports indicated that the center was located in eastern Minnesota with a barometer reading of 29.46 inches, sea level.

The tornado developed in the southeastern portion of the depression and about 200 miles from the center. It descended to earth at the southern city limits of Rockford, a city of about 85,000 people, and moved northeastward over the southeastern portion of the city for a distance of about 2¼ miles, affecting more than 30 city blocks. Passing across the Grant Highway east of town it moved into the country.

The first evidence of destruction was observed just outside of the city limits, where the roof and one gable were removed from a cottage. About 500 feet farther on a small dwelling, sheltering a family of 6, was completely demolished and the débris scattered over an open field for several hundred yards. While the parents were painfully injured and the children cut in numerous places all escaped death. To the northward at the adjacent house a man was found dead in the yard after the storm,



Ruins of chair factory in which eight persons were killed and many injured

Frame cottage turned upside down

his death probably caused by flying timber. Here the path was about 200 feet wide.

The next damage was the destruction of a chair factory, housed in a large brick-veneered structure of three floors and basement. Although 114 men were at work when the building collapsed only 8 were killed; however, almost two score were injured. The factory was evidently directly in the path of the storm, for the roof lifted and the sides fell, some inward and some outward.

Sweeping toward the northeast the storm cut a swath about 300 feet wide through alternating factory and residence districts, missing a grade school by several hundred feet. At one point, about 500 feet north of the storm track, 4 boys, 14 to 17 years old, were hurrying home to escape the storm when a garage roof came hurtling through the air. Two of the boys were killed instantly and a third died later. The fourth was unhurt. Lifting the roofs from dwellings, breaking windows, tearing off porches, and uprooting trees as it proceeded the storm did further damage by removing the south wall of a factory, dropping the contents of the second and third floors, including a large water tank, to the basement. Two men were killed.

Moving on through an area of residence, narrowly missing two more schools it hit a factory section, blowing out the south wall of one building and the north wall of another across the street to the south. With a path 400 feet wide it crossed a railroad, and passed over a section of new homes, missing the fourth school by 1 block, moving 2 adjacent houses out in the street with not a great deal of harm, damaging other residences with more or less severity. From this point the houses were scattered and open country was soon encountered. There was some skipping and scattered damage reported as far as Chemung. Several farm buildings were partially demolished and shade trees were broken down.

The visibility was good during the passage of the storm cloud, as workmen on a new building 3 miles away reported they saw the funnel-shaped cloud. There was much evidence of counter-clockwise motion and several walls were blown out. Débris was tossed out of the path toward the north. Porch roofs and eaves troughs were lifted and deposited on the main roofs, evidence of ascending air currents. The better class of structure withstood the storm's fury. A large reinforced concrete stack in the path was unharmed. There were some reports of hail, a very small amount. There was a moderate rain and some lightning. No fires were started.

The tornado struck the chair factory at 3:22 p. m. The exact time of other damage could not be determined with certainty, but the storm passed 2 miles south of Argyle and 1 mile north of Poplar Grove at 3:40 p. m., and the damage near Capron occurred near 4 o'clock. These facts indicate a velocity of forward movement of about 40 miles per hour. The length of the path was about 25 miles, the width varying from 200 to 500 feet. Fourteen deaths occurred and about 100 persons were injured in Rockford alone. Two hundred buildings were damaged or destroyed and the total property loss will amount to approximately $1,200,000.

THE DISTRIBUTION OF EXCESSIVE PRECIPITATION IN THE UNITED STATES

By ALFRED J. HENRY

Excessive rains as defined by the United States Weather Bureau may be conveniently grouped as follows:

Class A. Twenty-four-hour rains equalling or exceeding 2.50 inches.
Class B. Five-minute rains equalling or exceeding 0.25 inch.
Class C. One-hour rains equalling or exceeding 1 inch; in the later records as much as 0.80 inch in an hour is considered as excessive.

This classification is based essentially upon a time scale of heavy rains. For the full 24 hours any rain of 2.50 inches or more, regardless of the fact that it may have fallen in but 1 or 2 hours, is put into the same class as those which may have fallen at a uniform rate of but 0.104 inch per hour. It is possible, therefore, that a particular rain may be classed in two groups. A still further classification based on the month as a time unit was in use for a time in the early years of the Federal Weather Service. Ten inches per month was considered as excessive.

A rainfall of 0.25 inch in 5 minutes (class B) is, of course, equivalent to the rate of 6 inches per hour. The amount of rain that falls in any 5-minute period rarely exceeds 0.50 inch as a maximum.

In assembling the statistics for the above-named groups the 24-hour rains form a class by themselves, since they are drawn almost exclusively from stick measurements of the ordinary rain gage and eye observations of the times of beginning and ending of the rain.

Classes B and C on the other hand are drawn mainly from automatic records of rainfall that give both intensity and duration of the fall. In a small number of cases stick measurements of very intense rains whose time of beginning and ending is accurately known have been used.

TWENTY-FOUR-HOUR RAINS

The 24-hour rains equalling or exceeding 2.50 inches have been tabulated by States and for the year and also for the 3 summer months separately. The period covered by the tabulations is the same, viz, 1871–1894. A total of 3,886 records of which 357 were for summer months was used. The ratio of summer to annual frequency is, therefore, about as 1:10. West of the Rocky Mountains there is almost an entire absence of heavy rains in summer due to lack of moisture in the atmosphere and the prevailing high temperature.

The winter rainy season on the Pacific coast yields on the average about 40 heavy daily rains per season, practically all of them being associated with traveling cyclonic storms. East of the Rocky Mountains the convective rains of summer added to those associated with cyclonic storms, cold fronts, etc., increases the total number of these rains to more than double the number experienced on the Pacific coast.

It is commonly held and apparently with justification that the total precipitation decreases with distance from the chief storehouse of water vapor—the oceans. Whatever the precise relation may be it is modified by the topography of the lands bordering the oceans and the direction of the prevailing winds and even more profoundly by the temperature-altitude relations, a subject that will be more fully touched upon later.

Figure 1 shows the distribution of Class A rains for the year and Figure 2 that for the three summer months of June–August. The distribution shown in the annual chart resembles somewhat that of the annual depth of

precipitation in the United States, the number of occurrences of heavy 24-hour rains being nearly proportional to the depth of annual precipitation with the following exceptions:

(1) The large number of occurrences in the Gulf and Atlantic States may be attributed in part to the proximity of large water surfaces; some further influence, however, must be effective to explain the fact that in the middle Gulf region—the States of Alabama, Mississippi, and Louisiana—heavy 24-hour rains are only about 75 per cent as frequent as in Florida and Texas. The Florida Peninsula is almost surrounded by water, otherwise the relative position of land and water surfaces is about the same. Nearly all of the summer rainfall in the Gulf of Mexico region is of convective origin, and it may well be that local influences should be more favorable in Florida and Texas than in the other States.

(2) There is also a secondary maximum of heavy 24-hour rains in the interior of the continent—see the record for the States of Iowa, Kansas, Nebraska, Missouri, and Illinois—and this maximum can not be explained on the ground of proximity to large bodies of water or intense local evaporation. I am of opinion that

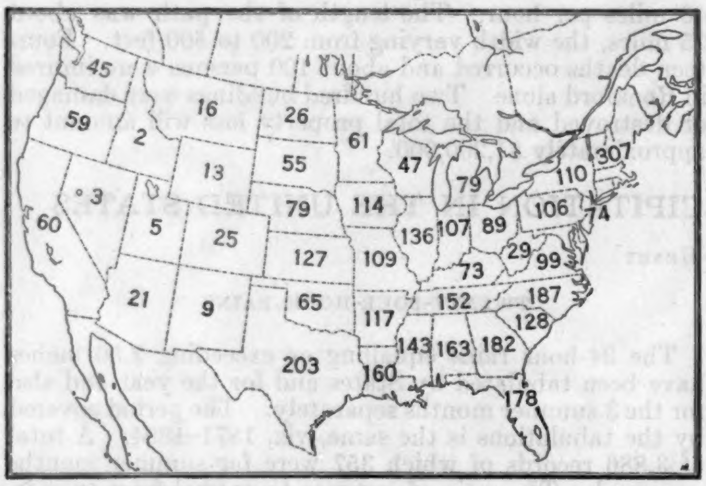


FIG. 1.—Distribution of 24-hour rains of 2.50 inches or more, total in 24 years, 1871–1894

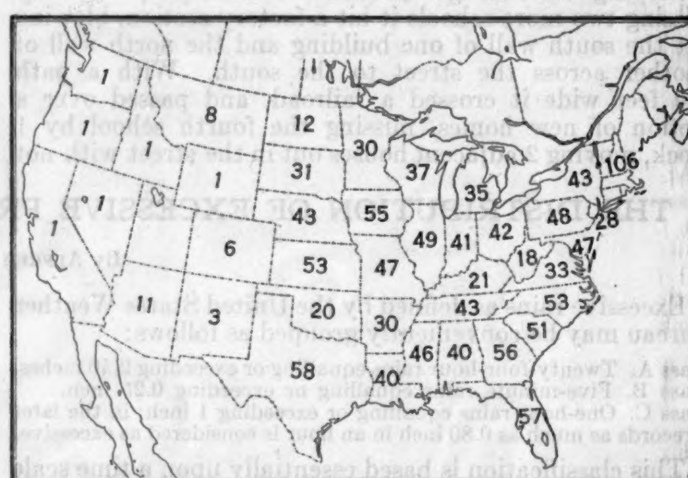


FIG. 2.—Distribution of excessive rains during summer for the five years, 1891–1895

the explanation will be found in the dynamic processes whereby warm moist air is permitted to ascend to elevations great enough to lower the temperature of the ascending moist air to its dewpoint, and thus to cause generous precipitation. This proposition assumes without proof, and there can be no direct proof, that in the warm seasons the atmosphere at the 3 to 4 kilometer level east of the Rocky Mountains is amply supplied at all times with sufficient water vapor to produce the observed rainfalls.

The old views on the causes of precipitation have given way to a certain extent to the modern conception of the atmosphere as being a series of concentric shells, each of which has the peculiar property that air which starts in any one shell can not be transferred to any other shell and remain there without the addition or subtraction of heat. The amount of water vapor in any shell, if large, greatly facilitates the air of that shell in rising to the level of condensation and thus causing generous precipitation.

A comparison of the data of Figures 1 and 2 shows that heavy 24-hour rains are frequent along the Gulf coast and in Florida, that the frequency diminishes with distance to the northward and then increases again in the lower Missouri Valley. It also shows a middle zone of lower frequency in Arkansas, Kentucky, West Virginia, and Virginia. Whether this decrease is real or due to a smaller number of rainfall records for these States I am not able to say. The distribution of rainfall stations is not uniform throughout the country, there being more stations along the eastern seaboard than in the interior or far Western States. It may be that if all States had as many and as long records of rainfall as are available for New England the frequency of heavy 24-hour rains would be greater than is here shown. The matter invites further study.

INTENSE RAINS OF SHORT TIME INTERVALS

I have used the records of 31 self-registering gages as summarized in Annual Report, Chief of Weather Bureau, 1895–96, pp. 247–64, for intervals of 5, 10, and 60 minutes. The summaries there published contain the records of 905 heavy downpours in 5 and 10 minutes. There is included in these summaries, however, the records of 53 rains of less intensity than was reached in the remainder of the rains. The explanation of this fact is, I take it, that it was thought necessary to give in each case of excessive rain for a 24-hour period the amount of rain for both the 5 and 10 minute and 1-hour periods regardless of whether those amounts were great enough to come within the classification adopted for the 5 and 10 minute rains. I have, therefore, eliminated 53 of the records printed in the summary above-mentioned, leaving a total of 853 records for analysis.

In reading off the numerical values from the original instrumental trace sheets there seems to have been a tendency on the part of the observers who made the original computations to allocate the amounts of rain for the individual storms around certain prominent figures, such as 0.20, 0.25, 0.30, 0.35 inch, etc. The following example will clarify my meaning.

Number of cases of 0.20 inch	201
Number of cases of 0.21 inch	30
Number of cases of 0.22 inch	55
Number of cases of 0.23 inch	36
Number of cases of 0.24 inch	31
Number of cases of 0.25 inch	130
Number of cases of 0.30 inch	94
Number of cases of 0.35 inch	55

It is evident that a frequency tabulation would have little meaning. I have, therefore, classed the 5 and 10 minute rains in an ascending series and present the results in Table No. 1.

TABLE 1.—*Rainfall intensities in 5 and 10 minutes classed as below, 1890–1895* [1]

Classes	Number in— 5 minutes	Number in— 10 minutes	Classes	Number in— 5 minutes	Number in— 10 minutes
0.20- inch	201	.....	0.71–0.80 inch	2	24
0.21–0.30 inch	451	192	0.81–0.90 inch		7
0.31–0.40 inch	140	316	0.91–1.00 inch		6
0.41–0.50 inch	35	172	1.01–1.10 inches		2
0.51–0.60 inch	14	89	1.11–1.20 inches		1
0.61–0.70 inch	7	41			

[1] 1 inch in 1 hour or less, 265.

The above tabulation shows that the most frequent 5-minute rains are found in the class 0.21 to 0.30 inch, both inclusive.

Similarly the most frequent 10-minute intense rains are found in the class 0.31 to 0.40 inch, inclusive. The upper limit of the most intense 5-minute rains is in the group 0.71 to 0.80 inch, in which group but two cases are found in the five years of record. In the 10-minute group the upper limit is in the class 1.10 to 1.20 inch and only a single case was found in the records.

The average rate per hour of the 5-minute group is 3.30 inches, that of the 10-minute group drops to 2.40 inches; hence it may be inferred that on the whole the maximum intensity of short-period rains is reached within 5 minutes, and that increasing the duration of the rain lowers the intensity.

TABLE 2.—*Rains equaling or exceeding a rate of 4.80 inches per hour, 1891–1895 (in 5 minutes)*

Stations	5 minutes	10 minutes	60 minutes or less	Duration in minutes	Stations	5 minutes	10 minutes	60 minutes or less	Duration in minutes
	Inches	*Inches*	*Inches*	*Inches*		*Inches*	*Inches*	*Inches*	*Inches*
Atlanta, Ga.	0.45	0.65	0.76	60	Memphis, Tenn.	0.40	0.70	0.95	56
	.45	.67	1.05	60		.55	.80	1.26	60
Bismarck, N. Dak.	.40	.61	.90	60	Milwaukee, Wis.	.42	.55	.68	53
	.75	1.00	2.00	60					
Boston, Mass.	.50	.80	1.50	60	New Orleans, La.	.68	.81	82	45
	.56	.83	1.68	60		.40	.75	1.76	60
Buffalo, N. Y.	.45	.75	1.70	60		.40	.67	1.12	60
Chicago, Ill.	.45	.80	1.60	60		.40	.55	1.23	60
	.40	.65	1.60	60		.40	.55	1.44	50
Cleveland, Ohio.	.47	.61	.61	10	New York, N.Y.	.60	.82	.90	60
						.40	.40	.41	25
Detroit, Mich.	.48	.50	.60	28		.42	.68	.91	45
	.60	1.00	2.15	60	Norfolk, Va.	.48	.91	1.00	60
Dodge, Kans.	.40	.60	1.00	46		.45	.80	1.50	60
	.47	.52	.63	60		.40	.66	2.20	60
	.50	.70	.95	60		.43	.63	1.71	60
Galveston, Tex.	.43	.83	1.46	60		.47	.75	1.45	60
	.40	.75	1.75	60	Omaha, Nebr.	.50	.80	1.00	35
	.45	.75	.85	30		.50	.75	1.32	60
	.54	.93	2.32	60	Philadelphia, Pa.	.45	.67	.85	28
Indianapolis, Ind.	.45	.65	1.60	60					
	.55	.65	.92	60	St. Louis, Mo.	.40	.51	.86	60
	.45	.56	.57	60		.40	.64	.97	60
	.42	.53	.69	60	St. Paul, Minn.	.70	1.00	1.30	60
	.49	.64	.71	60		.40	.70	1.35	25
Jacksonville, Fla.	.62	1.18	2.20	60		.50	.70	1.10	51
	.60	.90	1.08	60		.40	.65	1.13	60
	.45	.80	1.30	23	Savannah, Ga.	.40	.50	.71	24
	.54	.50	.66	60		.40	.65	1.35	60
	.40	.46	.87	60		.45	.80	2.20	60
	.50	.77	1.73	60		.40	.80	1.10	60
	.55	.85	1.02	60		.40	.75	1.10	42
	.45	.75	1.75	60		.40	.70	1.05	60
	.45	.70	1.48	60		.47	.92	1.90	40
	.45	.53	.72	60		.50	.75	1.70	60
Kansas City, Mo.	.40	.80	1.55	60		.50	.90	1.98	60
	.45	.56	.95	60		.42	.70	.96	60
	.65	1.10	2.40	60		.58	1.05	2.28	60
	.47	.73	2.20	60		.43	.65	1.89	60
Key West, Fla.	.45	.65	1.56	60	Washington, D. C.	.40	.50	.65	58
	.41	.65	.90	33		.42	.68	.80	60
	.45	.80	1.13	60					
	.44	.72	1.85	33					
	.42	.65	1.13	50					

Another form of comparison leads to the result that the rate per hour during the 5-minute interval increased after passing to the 10-minute interval in but a fraction of 1 per cent of the total number of cases; the rate per hour held the same in 3 per cent and decreased in the remaining 97 per cent. As further illustrating variations in the intensity of the short-period rains, I have selected from both groups those rains having an hourly rate of not less than 4.80 inches for a 5-minute interval and have given the amount of rain that fell in each of these heavy downpours for intervals of 5, 10, and 60 minutes, respectively, in Table 2.

In this table there are 24 cases having the minimum rate of 4.80 inches per hour. The same 24 rains carried through a 10-minute period yield a rate of but 3.60 inches per hour and when carried through a period of 1 hour the rate sinks to 1.13 inches.

The geographic distribution of these rains is much the same as shown in Figure 2, except for the much greater frequency along the coast of the Gulf of Mexico and the coasts of Georgia and Florida. The intensity of the rains, however, is not greatly different as between coastal areas and the interior. In fact the greatest 5-minute intensity for the 5-year period occurred at Bismarck, N. Dak., far in the interior of the Continent. In the 10-minute period rains of great intensity have occurred at both Kansas City, Mo., and St. Paul, Minn. In the 1-hour class the greatest fall occurred at Kansas City, Mo., with Galveston, Tex., a close second.

The greater frequency of intense short period rains along the Gulf coast is doubtless due to the fact that the temperature of the dew point on the average, is much higher in winter and spring than it is in the northern frontier States.

It, therefore, follows that heavy rains occur along the Gulf coast throughout the year, whereas the average temperature of the dew point at Bismarck, N. Dak., for example is so low in winter that precipitation as rain is quite out of the question.

The average dew point at Galveston in winter is 40° to 45° higher than at Bismarck. In summer the difference is less—from 18° to 22° on the average.

The higher the temperature of the air, the greater its capacity for water vapor whence it follows that the precipitation must be more frequent and in larger amount in those regions having the higher dew point.

OCCURRENCE OF SHORT PERIOD EXCESSIVE RAINS AN ISOLATED PHENOMENON

On the whole the occurrence of excessive precipitation except in tropical cyclones, is more apt to be an isolated than a phenomenon of general distribution; occasionally, however, certain barometric depressions are exceptionally rich in excessive rainfall. On August 20–22, 1924, a rather weak depression of the trough type moving eastward north of the Dakotas gave excessive rain at Bismarck, N. Dak., and Moorehead, Minn., on the 20th and on the 21st at Minneapolis and St. Paul, Minn., Dubuque, Iowa, Wausau, Wis., Houghton, and Sault Ste. Marie, Mich. And on the 22d at Ludington and Grand Haven, Mich., Sandusky, Ohio, and Rochester, N. Y. The most remarkable feature, however, was two excessive rains on the 21st at both Minneapolis and St. Paul, Minn.

A summary of these rains follows:

Station (Aug. 21)	Excessive rain—			
	Began	Ended	Amount	Duration
	A. m.	*A. m.*	*Inches*	*Minutes*
Minneapolis	2.19	3.12	1.54	60
Do	6.58	8.02	1.57	80
St. Paul	2.37	3.25	1.08	50
Do	7.18	7.50	.90	45

The two gages in which the above amounts were recorded are about 10 miles apart, Minneapolis being to the northwest of St. Paul, and it will be noticed that there is a short time lag in the beginnings and endings at St. Paul as compared with Minneapolis, thus indicating a progressive movement of the rain at the rate of about 10 miles per hour. The total amounts at Minneapolis—the northwestern station—are greatest, thus perhaps indicating that the intensity of the rains was diminishing.

The source of the water vapor that produced at Minneapolis an inch and a half of rain in the early morning of the 21st and another like amount about 3 hours later, can not, of course, be definitely known. The surface winds before the rain began were from the southeast and the speed about 25 m. p. h. About 5 minutes before the excessive rain began the wind shifted to northwest and continued from that direction, although quite variable throughout the rain when it became northeast, and then east and southeast, continuing from those directions until the beginning of the second excessive rain. Then, as before, the wind suddenly shifted to the northwest soon becoming northeast and southeast after the rain had ended. It continued from those directions about 8 hours before finally backing to northwest through south and southeast.

The conclusion seems unavoidable that, not only was the vapor content of the air over the two stations much higher than the average, but also that the cooling which produced the condensation was in the nature of an intermittent advance of a cold front which, judging from the temperature did not extend to the surface as a solid current of cold air in either case.

The fact that both rains occurred during the hours when vertical convection must have been at a minimum lends support to the idea that the cooling at the level of condensation must have been due to the underrunning of colder air as the most probable cause of the excessive rains.

The cyclonic storm of July 7, 1915, with circular isobars and much stronger barometric gradients than are usually associated with a midsummer cyclone moved from eastern Nebraska on the morning of the 7th to Eastport, Me., by the morning of the 9th and central pressure fell to 29.16 inches by that time.

This storm was attended by numerous early morning thunderstorms in the middle Mississippi and lower Ohio Valleys and by heavy though not excessive rains in New England. The 24-hour rainfall was more than 3 inches at Binghamton, N. Y., Greenville and Portland, Me., and smaller amounts at other places. Excessive rains fell on the 7th at Davenport, Dubuque, and Keokuk, Iowa; Hannibal and St. Louis, Mo.; Chicago, Peoria, Springfield, and Cairo, Ill.; Terre Haute and Indianapolis, Ind.; Lexington, Ky., amd Dayton and Cincinnati, Ohio. Information as to the thermal stratification of the atmosphere in this cyclone is of course lacking.

THE AMOUNT OF AQUEOUS VAPOR IN THE ATMOSPHERE

The late Prof. C. Abbe, using Hann's law of the diminution of aqueous vapor with increasing altitude, computed the total amount of water vapor in the atmosphere up to 30,000 feet, (5.7 mile, 9.1 km.) in terms of depth of rain that it would produce if all were condensed. Abbe's results were based on the average surface dew point at the station; it rarely happens, however that rain falls when the dew point is at its average value, on the contrary rainfall generally occurs when the dew point is relatively high, hence the computed results are too low.

In 1915 the greatest excessive rain in any consecutive 24 hours was recorded at Iola, Kans., 4.90 inches in 1 hour and 25 minutes and the second greatest in the same year occurred at Corpus Christi, Tex., 4.70 inches in 1 hour and 20 minutes. At Iola the dew point just before the rain was 66° or 5° above the average for the month. The dew point at Corpus is not available. In both cases the excessive rains were associated with thunderstorms, except that at Corpus 2.09 inches of rain fell outside of the thunderstorm periods. For these 2 regions Abbe's computations based on the average dew point give 0.6 and 1.3 inches, respectively, the smaller amount being for Kansas and the larger for Texas. The actual rainfall was therefore six times as great as that computed at Iola and about four times as great at Corpus.

In the case of the last-named place the wind circulation may have brought fresh masses of saturated air over the station but at Iola the pressure gradient was not favorable to the indraught of air from outside regions; the gradients were weak and mostly for light south and southeast winds. In any event the fact remains and this is the point to be emphasized, that at this station, almost in the centre of the North American Continent the vapor content of the atmosphere as shown by the measured rainfall in less than 24 hours' duration was as great as at a point on the coast of the Gulf of Mexico, where all natural conditions were conducive to a high vapor content of the atmosphere.

The above is not an isolated case. At Topeka, Kans., in June of the same year 3 excessive rains were recorded as follows:

June 10, 4:19–4:35 a. 0.49 inch in 20 minutes.
June 10, 6:52–8:14 p. 2.02 inches in 100 minutes.
June 10, 9:24–9:39 p. 0.65 inch in 15 minutes.

At Minneapolis, Minn., 2.38 inches fell in 80 minutes, and this was followed later in the day by 0.47 inch in 15 minutes. While such cases can not be multiplied indefinitely, there are enough of them to cause us to believe that our knowledge both of the source and amount of aqueous vapor in the atmosphere is incomplete.

THE 3-DAY RAIN OF OCTOBER 4–6, 1910

This paper would be incomplete without reference to the continued rains of October 4–6, 1910. This was an extraordinary rainstorm coming as it did in one of the dry months of one of the driest years ever experienced in this country. It had one feature in particular that is seldom found outside of tropical cyclones, viz, a concentration of heavy rains in one or more separate areas. In this in-

stance there were at least 4 such areas, 2 in Arkansas, and 1 each in southeast Illinois and Missouri. The 3-day totals for each of these areas follow:

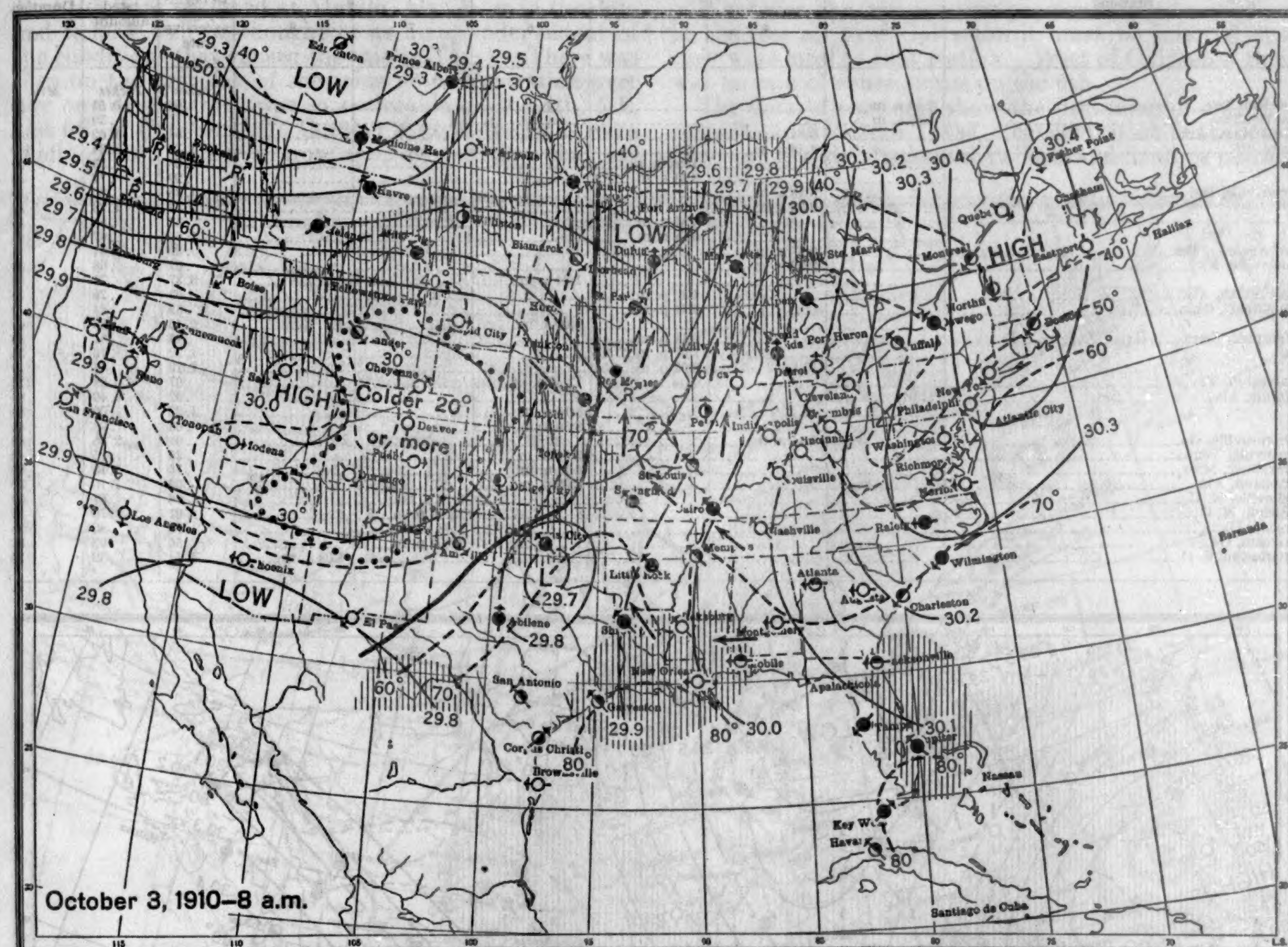


FIG. 3a.—Daily weather map

	Inches
Bee Branch, Ark	11. 50
Marked Tree, Ark	13. 99
New Madrid, Mo	13. 30
Golconda, Ill	15. 18

The longer axis of the storm, as may be seen from Figure 4 extends in a NE.-SW. direction, closely paralleling the Ohio River from Cincinnati to the mouth at Cairo. It may be only a coincidence but the area of heavy precipitation as here figured is very nearly coextensive with that of large tornado frequency in the United States.[1] The area inclosed by the isohyet of 7 inches includes approximately 42,000 square miles. In and close to this area there were 16 self-recording rain gages 13 of which gave a record of excessive rains. Five other gages outside of this central region furnished records of the duration and intensity of the precipitation for other parts of the same storm. I have summarized these 21 records in Table 1 and present it as a record of perhaps the most widespread heavy rainstorm that has occurred in many years.

[1] There are reasons for believing that the atmospheric conditions which produce thunderstorms and tornadoes are closely related. These conditions are nowhere so fully developed as in the great interior valleys between the Rockies on the West and the Appalachians on the East.

TABLE 1.—*Excessive rains October 3–8, 1910*

Stations	October, 1910						Amount previous to beginning of excessive rate	Accumulated amount	Duration
	3	4	5	6	7	8	*Inches*	*Inches*	*Min.*
Del Rio, Tex	2:14 a. m.						0.06	0.51	20
Taylor, Tex	7:53 a. m.						0	.39	10
Little Rock, Ark		12:45 a. m.					.04	1.62	100
Cairo, Ill		4:18 a. m.					1.78	3.34	180
			12:47 a. m.				.08	.53	20
			8:51 a. m.				.29	.77	50
Evansville, Ind		8:13 a. m.					1.38	.86	50
		9:38 a. m.					2.32	1.23	50
			3:47 a. m.				.53	.85	50
			6:08 a. m.				1.66	.97	45
San Antonio, Tex		9:47 a. m.					.29	.44	15
Louisville, Ky		2:22 p. m.					.01	.68	30
				1:34 a. m.			3.37	.75	45
Fort Smith, Ark			4:40 p. m.				.03	.79	20
Cincinnati, Ohio			4:41 p. m.				.32	.64	40
				3:00 a. m.			2.46	.86	40
Memphis, Tenn			6:11 p. m.				.46	.61	30
			7:41 p. m.				1.32	.76	35
			8:52 p. m.				2.12	.44	10
Galveston, Tex				12:42 a. m.			.07	6.28	120
Mobile, Ala	11:04						.02	1.40	80
				3:16 a. m.			1.23	1.00	80
				8:36 a. m.			.03	.93	45
Thomasville, Ga		5:41 p. m.					.01	2.35	80
Nashville, Tenn				3:54 a. m.			.25	.75	40
Vicksburg, Miss				4:11 a. m.			.15	1.13	80
Anniston, Ala				3:05 p. m.			.02	1.10	80
Asheville, N. C					3:29 a. m.		.66	.51	30
Raleigh, N. C					12:49 p. m.		.01	.70	35
Macon, Ga					5:48 p. m.		.70	.80	35
Augusta, Ga					10:00 p. m.		.56	.92	50
Charleston, S. C						4:03 a. m.	1.14	.39	10

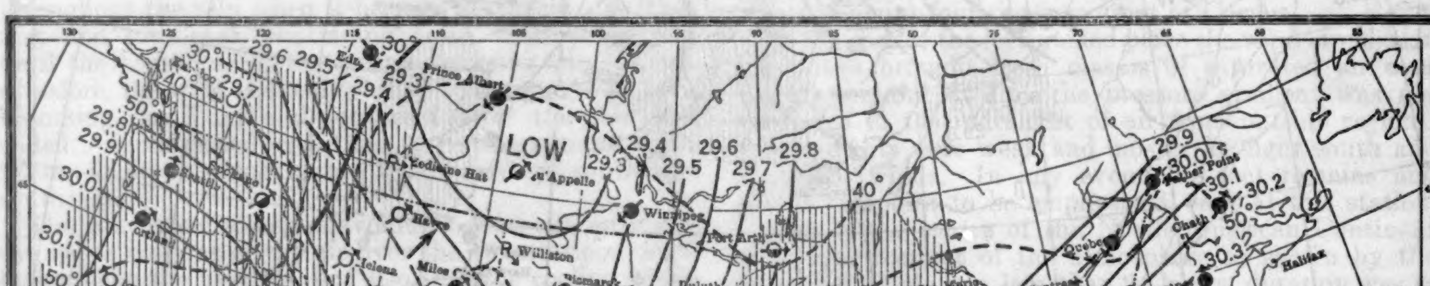


FIG. 3b.—Daily weather map

This table shows that the first excessive rain fell on October 3 in the Rio Grande Valley at Del Rio, Tex.; the second in point of time at Taylor, Tex., almost directly northeast and distant about 200 miles from Del Rio; the third occurred at Mobile, Ala., later in the day, and it may well be thought of as being independent of the conditions that caused the rain in Texas. There was then on the first day of the rains no concentration over any one district that was so noticeable on the 4th, 5th, and 6th of October. On October 4 excessive rains were confined to a rather narrow strip of territory that extended in a NE.-SW. direction from San Antonio, Tex., to Louisville, Ky., with great intermediate spaces where, perhaps from a lack of gauges, no records were obtained. In this strip several weather bureau stations are located, each having an automatic gauge in operation. It so happened that good records, both of duration and intensity, were obtained, particularly at Cairo, Ill., Evansville, Ind., and Memphis, Tenn.

The most striking fall was that recorded at Galveston, Tex., on the 5th, viz, 6.28 inches in 2 hours. The unusual feature being not so much the amount and intensity of the fall at Galveston as the relatively small rains inland a few miles.

At Houston, Tex., about 50 miles inland from Galveston, the fall was but 0.43 inch, and at 16 other stations near the coast individual falls ranged from zero to 1.40 as the largest, the average being 0.50 inch.

Whatever the temperature-pressure-altitude relations in the free air over Galveston it must be inferred that they were local to that station. West of Galveston there was no rain of consequence on the 6th.

The data of the table show the beginning of excessive rains in southwestern Texas, a concentration in the lower Ohio and middle Mississippi Valleys, and finally a passage off to sea over the coast of South Carolina on the early morning of the 8th.

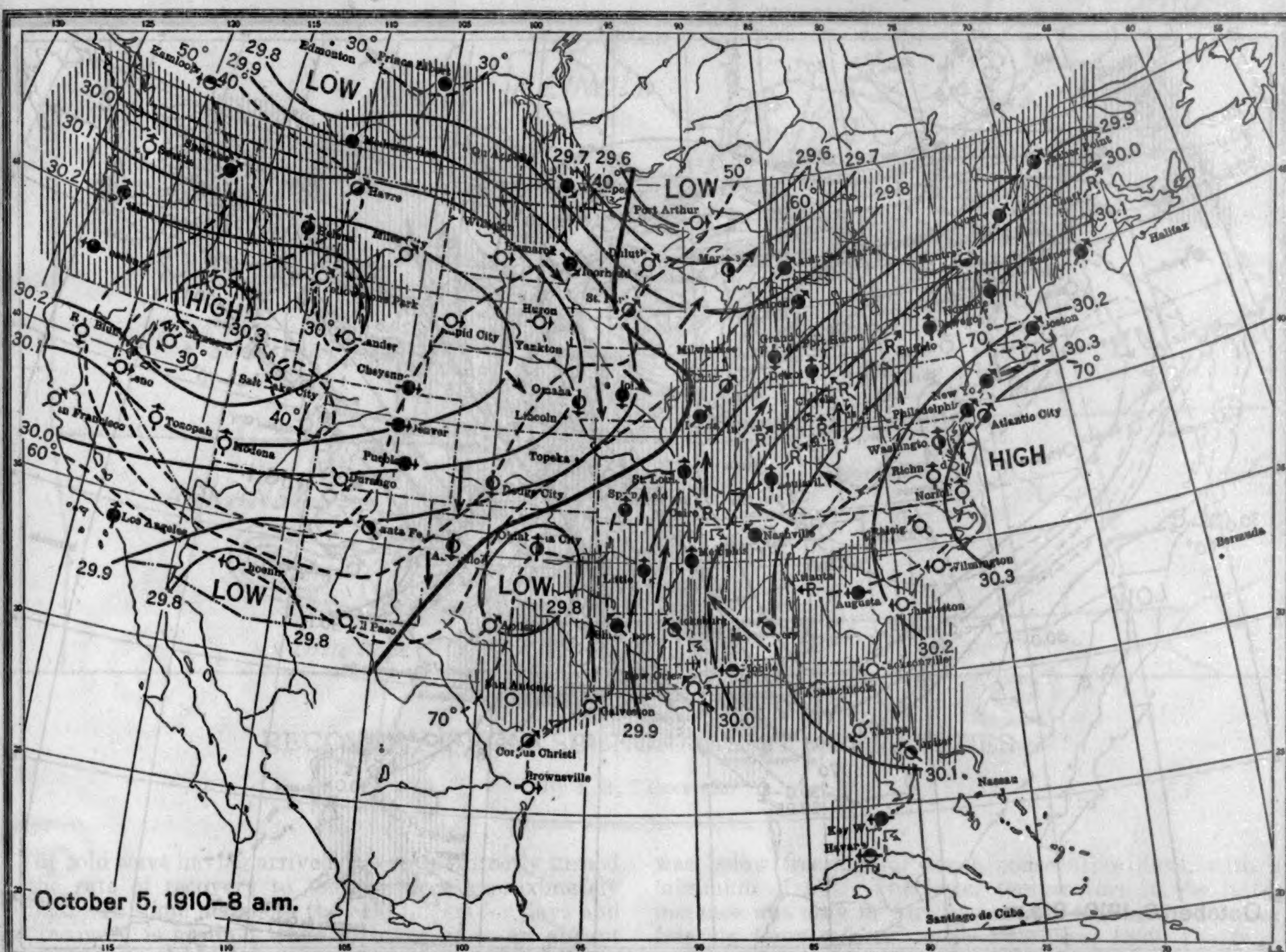


FIG. 3c.—Daily weather map

I now pass to a consideration of the daily weather charts, October 3 to 6th, both inclusive.

The charts, Figure 3.—To those accustomed to read them the charts speak for themselves; to the lay reader they very likely mean but little. The essential features are as follows:

October 3, beginning of the rains.—A trough of low-pressure stretches from Texas to the Canadian border and is flanked on either side by high pressure, that over New England being much the higher of the two. The western area, however, is associated with a fall of about

20° in the surface temperature that had advanced into the western borders of the plains States of Nebraska, Kansas, and Oklahoma.

October 4, beginning of heavy rains in Missouri.—The outstanding feature of this chart is the advance of a fresh depression of the barometer from the Canadian Northwest. This depression was of the V type, its southern end, the apex of the V had extended well into the Plains States. The pressure trough of the 3d has remained in practically the same position it was in on that date, except that the northern end is a little farther to the eastward than the southern. The wind shift line of the 3d has now disappeared east of the Rocky Mountains and a fresh trough of low pressure has advanced over the region occupied by a similar one 24 hours earlier.

October 5, second day of heavy rains.—As just stated a second trough of low pressure now occupies almost the identical position of that which overlaid the same region on the 3d and 4th. This is the keynote of the situation and fully explains the continuance of heavy rains over the region in question. I have drawn the wind shift line for each of the dates and have indicated by the large arrows on either side of it the general drift of the surface layers of air—from the south on the east or warm side and from the north on the west or cool side. It is reasonable to assume that the thermal stratification of the atmosphere where the heavy rains fell was such as to warrant the fall of rain as recorded at the several rainfall stations. Unfortunately no data are available for the free air over the interior valleys on the dates in question, but enough is known from the pressure formations as indicated in the charts to infer that the surface wind directions also prevailed aloft and judging from the amount of precipitation that occurred there must have been enough speed to have brought in large masses of air from distant regions.

Fig. 3d.—Daily weather map

October 6, conclusion of heavy rains.—On this date heavy rains fell only in western Kentucky and western Tennessee, also in the extreme southeastern tip of Missouri, thus showing that the overlapping of the two troughs of low pressure was not great. The width of the zone of greatest rainfall at its widest point was about 250 miles and its extreme length about 600 miles.

Finally, the outstanding result of this study is the fact that the atmosphere over the United States, say east of the one-hundredth meridian contains during the warm season a high water content which awaits only suitable temperature relations in order to produce excessive rains for a short period of time.

The longer excessive rains (24 hours) are due as a rule to any one of the following conditions: The advent of a tropical cyclone along the Gulf and the eastern seaboard. The seemingly fortuitous relative geographic position with reference to each other of a vigorous extratropical cyclone with a strong anticyclone immediately to the northeast. The same condition, although in a slightly different form, viz, the intrusion of an anticyclone (cold front) into an extensive barometric trough wherein high temperature and vapor content in the atmosphere prevail, also causes excessive rains for 24 hours and sometimes longer.

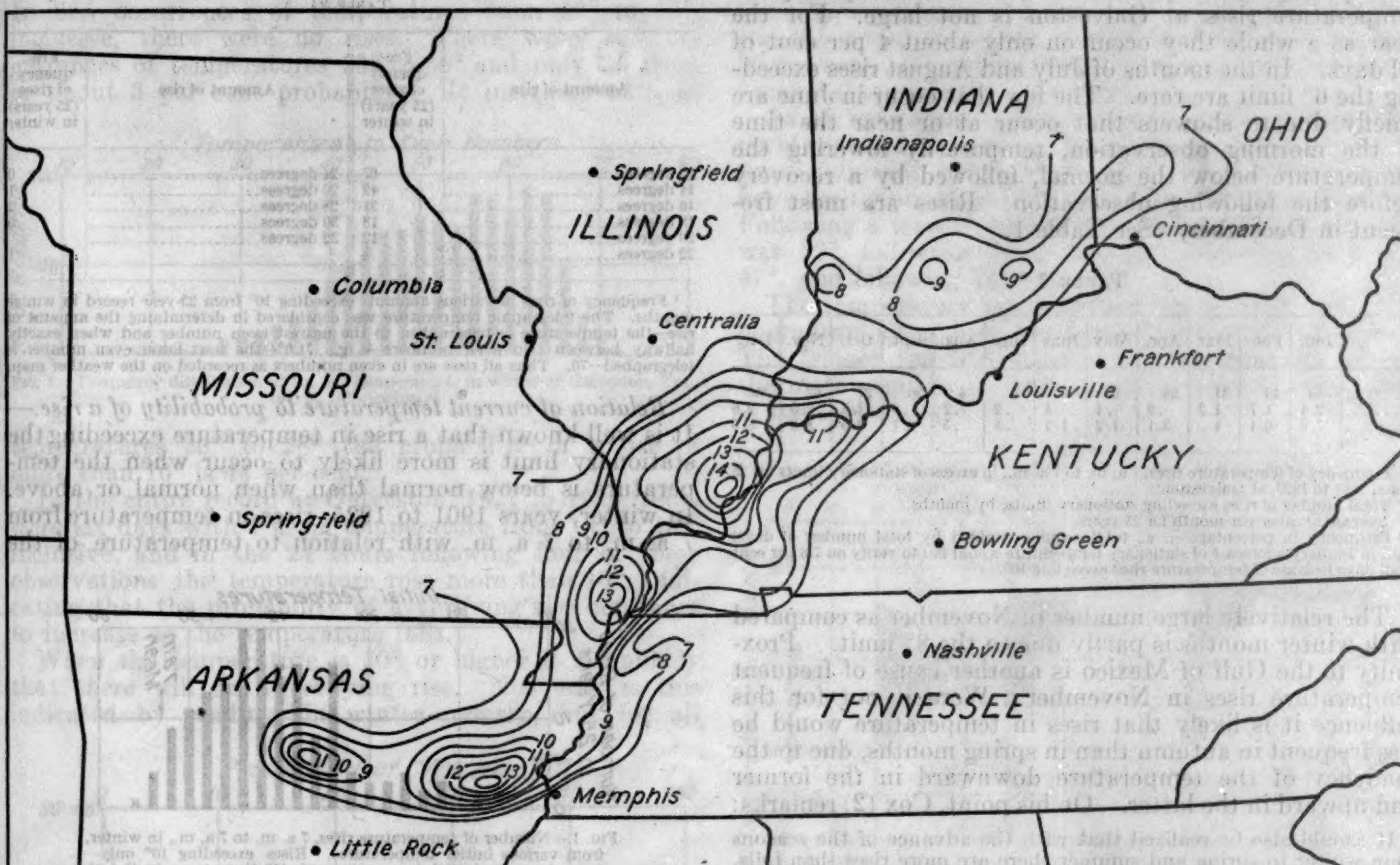


FIG. 4.—Heavy rains in Ohio Valley, October 4-6, 1910

RECOVERY FROM SUBNORMAL TEMPERATURES

By I. R. TANNEHILL

[Weather Bureau, Galveston, Tex.]

The cold wave having arrived, interest is directly turned to the rate of recovery to temperatures approximately normal. In some instances the cold lingers for days and the recovery is gradual while in other cases an abrupt change to much higher temperatures quickly follows. Public interest in the return to seasonable conditions is aroused not alone by its effect upon human comfort but because the rate of recovery is one of the factors determining the extent of injury to vegetation.

In discussing injurious temperatures, Young (1) says:

> So many factors must be taken into consideration in determining whether a given temperature will cause damage that the matter is one of great complexity. The length of time the low temperature persists, the vigor and stage of advancement of the plant, the kind of weather preceding the frost, and the rate of thawing all have considerable influence on the amount of damage that will be done.

The marked differences in rate of recovery from cold waves at Galveston is illustrated by the occurrence in January, 1887, of a temperature of 24° with only one day below freezing, while in January, 1886, the temperature was below freezing for seven consecutive days, with a minimum of 11°. The lower temperature in the latter instance was only in part responsible for the duration of freezing temperatures, as in February, 1899, the temperature fell to 8° with only three days below freezing.

This study was undertaken to determine the relative frequencies of temperature rises of various magnitudes, the relation of current temperature to the probability of a rise, and the influence of pressure distribution upon the rate of recovery from low temperatures.

As a basis for the study, all 7 a. m. temperatures in the period 1901 to 1925, inclusive, were examined, numbering 9,131 in all. Files of weather maps covered the periods 1901 to 1905 and 1914 to 1925, though not complete for the latter period. Weather maps and temperature changes in the winter months were studied chiefly, because at that season the frequency and average magnitude of temperature rises are greatest.

For the purposes of this paper a temperature rise is considered only when exceeding the stationary limit, namely, 10° in December, January, February, and March,

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8° in April, May, October, and November, and 6° in June, July, August, and September. The rise is the difference in temperature from the 7 a. m. reading of one day to the 7 a. m. reading of the next following day. Temperature changes taking place between 7 p. m. readings were not tabulated.

Frequency of temperature rises.[1]—The frequency of temperature rises at Galveston is not large. For the year as a whole they occur on only about 4 per cent of all days. In the months of July and August rises exceeding the 6° limit are rare. The few that occur in June are chiefly due to showers that occur at or near the time of the morning observation, temporarily lowering the temperature below the normal, followed by a recovery before the following observation. Rises are most frequent in December, See Table 1.

TABLE 1[1]

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
1[2]	59	43	31	23	9	9	4	4	20	27	62	66
2[3]	2.4	1.7	1.2	.9	.4	.4	.2	.2	.8	1.1	2.5	2.6
3[4]	7.6	6.1	4	3.1	1.2	1.2	.5	.5	2.7	3.5	8.3	8.5

[1] Frequency of temperature rises, 7 a. m. to 7 a. m., in excess of stationary limits for 25 years, 1901 to 1925, at Galveston.
[2] Total number of rises exceeding stationary limits, by months.
[3] Average number per month for 25 years.
[4] Frequency in percentage—i. e., total number divided by total number of days; e. g., in January a forecast of stationary temperature would fail to verify on 7.6 per cent of all days because of temperature rises exceeding 10°.

The relatively large number in November as compared with winter months is partly due to the 8° limit. Proximity to the Gulf of Mexico is another cause of frequent temperature rises in November. Were it not for this influence it is likely that rises in temperature would be less frequent in autumn than in spring months, due to the tendency of the temperature downward in the former and upward in the latter. On his point, Cox (**2**) remarks:

> It should also be realized that with the advance of the seasons from winter to spring and summer there are more rises than falls, while with the approach of autumn and winter the reverse is true.

In the 25 years noted above there were 31 rises in March exceeding 10° and 62 in November exceeding 8°. In March there were 51 rises exceeding 8°, the November limit. In April and May combined there were 32 rises exceeding 8°, while in October and November there were 89.

In the autumn and early winter the land temperatures fall more rapidly than the water temperatures, and when the wind shifts to a southerly direction its temperature is higher, relative to air from the land, than in spring months, when the water remains relatively cool. This effect is evidently more pronounced than that of the advancing seasons. It is seen, also, in the relative frequencies of December and February rises—66 in the former and 43 in the latter. The effect becomes most pronounced in late spring when a north wind causes morning temperatures to fall and evening temperatures to rise. The temperature falls from 7 p. m. of one day to 7 p. m. of the next when the wind shifts from northerly to southerly. A forecast of "warmer to-morrow" at that season is not verified under the same pressure conditions as at other seasons.

Frequency of rises of various magnitudes in winter is shown in Table 2. Rises in excess of 20° are rare. Only eight were recorded in the 25 years of winter record. The maximum occurred on December 22, 1916 (32°).

[1] Rises are taken from the telegraphic reports. The Weather Bureau reports the temperature by telegraph to the nearest even number—odd numbers are not sent and if the number is exactly odd, as 69.0, the next lower even number is sent, 68.

In the records prior to 1901 this has been exceeded. In February, 1899, the temperature rose from 11.4° at 7 a. m. of February 13 to 45.7° at 7 a. m. of February 14, a rise of 34.3°, or from telegraphic amounts, 34°. At Galveston this is a phenomenal rise. Temperature falls, in cold waves, frequently exceed the greatest rises (**3**).

TABLE 2[1]

Amount of rise	Frequency of rises (25 years) in winter	Amount of rise	Frequency of rises (25 years) in winter
12 degrees	67	24 degrees	0
14 degrees	42	26 degrees	1
16 degrees	21	28 degrees	2
18 degrees	18	30 degrees	0
20 degrees	12	32 degrees	
22 degrees	4		1

[1] Frequency of rises of various amounts exceeding 10° from 25-year record in winter months. The telegraphic temperature was considered in determining the amount of rise—the temperature is telegraphed to the nearest even number and when exactly halfway between two even numbers—e. g., 71.0°—the next lower even number is telegraphed—70. Thus all rises are in even numbers as recorded on the weather map.

Relation of current temperature to probability of a rise.—It is well known that a rise in temperature exceeding the stationary limit is more likely to occur when the temperature is below normal than when normal or above. In winter, years 1901 to 1925, rises in temperature from 7 a. m. to 7 a. m. with relation to temperature of the first observation have been distributed as shown in Figure 1. A change to warmer exceeding 10° has occurred most frequently from temperatures of 42° to 44°. The average 7 a. m. temperature for this period was 53°. Thus, rises occurred most frequently from readings 10° below the normal. However, this does not indicate the manner in which the probability of a rise varies with the temperature level. Temperatures of 42° to 44° occur more frequently than lower readings and therefore there is greater opportunity for a rise from that level.

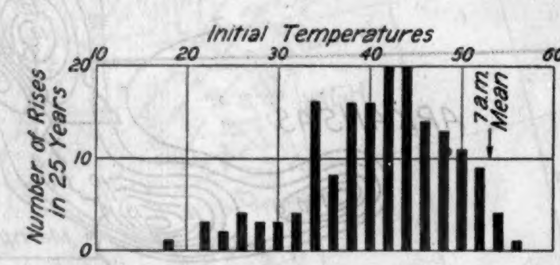

FIG. 1.—Number of temperature rises, 7 a. m. to 7 a. m., in winter, from various initial temperatures. Rises exceeding 10° only—i. e., from an initial temperature of 42° there were, in the 25-year period 1910 to 1925, 20 rises exceeding 10°

A frequency distribution of 7 a. m. temperatures is shown in Figure 2. All the 7 a. m. readings in winter months, 1901 to 1925, inclusive, are used, totaling 2,256. The mode is at 62°, apparently, and the mean 53°. The distribution is decidedly unsymmetrical. In this, as in the preceding figure, only telegraphic amounts are considered. When actual temperatures are tabulated, the even readings preponderate, due to personal bias and to the rule for dropping decimals (**4**). These ininfluences are removed by using the even values as telegraphed, and it is probable that the irregularities in the distribution are purely chance and would be removed should a much larger number of observations be used.

Dividing the frequency of rises by the frequency of the initial temperature, we obtain the probability that the temperature will increase by more than 10°,

as related to the temperature level—e. g., there were 80 occurrences of temperature 40° and in 16 cases the succeeding temperature was higher by more than 10°, making the probability 20 per cent.

Grouping the temperatures by 10° intervals and computing the probabilities, it is found that the probability of a rise increases as the temperature falls. See Figure 3. In 665 occurrences of temperatures from 60° to 68°, inclusive, there were no rises. There were 793 occurrences of temperatures 50° to 58° and only 25 rises, or about 3 per cent probability. It increases until at

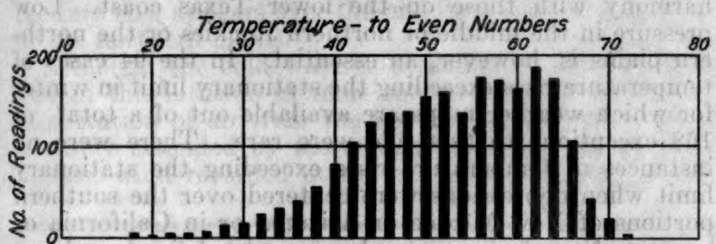

FIG. 2.—Frequency distribution of 7 a. m. temperatures in winter at Galveston, Tex., 1901 to 1925, inclusive

temperatures 20° to 28° the probability of a rise of more than 10° is 44 per cent.

In the entire record at Galveston, 1871 to 1925, there were six days with 7 a. m. temperature from 10° to 18°, inclusive, and in the 24 hours following four of these observations the temperature rose more than 10°, indicating that the probability of a verifying rise continues to increase as the temperature falls.

When the temperature is 50° or higher it is unlikely that there will be a verifying rise. Not only is this indicated by readings in winter months, but for all

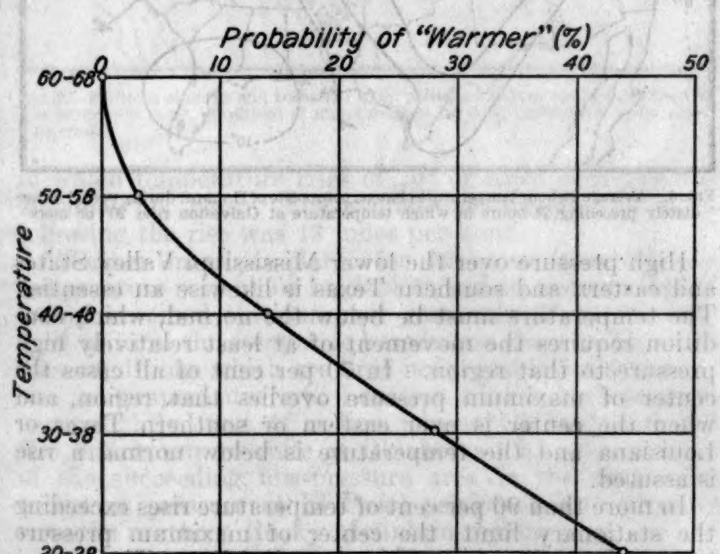

FIG. 3.—Probability of *warmer* as related to the temperature level

months rises from temperatures at or above the normal are quite rare. It may be stated positively that when the 7 a. m. temperature equals or exceeds the normal 24-hour mean for that day, the temperature in the ensuing 24 hours will not rise an amount exceeding the stationary limit for that season. In the 25 years studied there has been only one exception to this rule. The normal temperature for November 18 is 62°. On November 18, 1906, the 7 a. m. temperature was 64° and at 7 a. m. on November 19 it was 73.6°, showing an increase in telegraphic amounts of 10°, exceeding the 8° stationary limit for November. No other instance of a verifying rise from a temperature above the normal 24-hour mean has been found.

Tendency for subnormal temperatures to persist.—Though the tendency to rise increases as the temperatures become lower, the frequency of these rises is not in accord with the laws of chance. At temperature 40° the probability of a rise would be about 60 per cent, because there are 1,327 readings at and above 52° out of a total of 2,256, but the actual frequency of rises from 40° is only about 20 per cent. Therefore there is a strong tendency for an abnormal temperature to persist.

As an indication of the influence of the current temperature upon succeeding temperatures, all readings, 24 hours following temperatures of 64°, 54°, 44°, and 34°, have been grouped in frequency distributions in Figure 4. Following a temperature of 64° the mean 24 hours later was 58°, following 54 it was 55°, following 44 it was 47°, and following 34 it was 43°.

The temperature tends toward the normal, but in 24 hours insufficient time has elapsed for complete recovery. The farther the temperature departs from the normal the more rapid is its rate of return toward the normal in the average case.

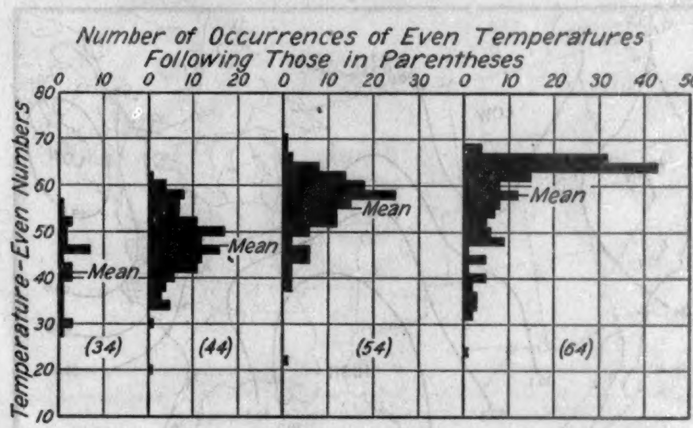

FIG. 4.—Frequency distributions of 7 a. m. temperatures 24 hours after an initial temperature of 64°, 54,° 44°, and 34°, in winter at Galveston, Tex., showing that the temperature tends to return to the normal, but the recovery in 24 hours is not complete

Point from which warm wave advances.—The cold wave which reaches the Texas coast with marked force arrives from the far Northwest, first appearing on the weather map as an "Alberta HIGH" and moving through the western portion of North Dakota or Montana (5). Strangely, the warm wave moves southeastward from precisely the same position. The temperature rise results partly from the flow of air from lower to higher latitudes, and this flow sets in first in the Northwest and progresses southeastward. There are other causes of the temperature rise. Speaking of the rise of temperature above the seasonal average, in advance of cold waves, Henry (6) said:

> The air is heated in front of a cyclone, not alone by the importation of relatively warm air from lower latitudes but as a result of other atmospheric conditions which operate to prevent loss of heat by radiation at night and to conserve the heat gained by day through solar radiation.

These remarks apply to the cyclone which follows the cold wave as well as to the one which precedes.

Conditions in advance of the temperature rise are shown in the following, from a study of a number of warm waves in the period 1901 to 1925. During these years there were in winter 20 instances in which the temperature rose 20° or more in 24 hours, 7 a. m. to 7 a. m. The dates, amount of rise, and initial temperature are shown in Table 3.

TABLE 3[1]

Date	Amount of rise	Initial temperature	Date	Amount of rise	Initial temperature
	°	°		°	°
Feb. 24, 1901	20	36	Jan. 14, 1916	22	34
Dec. 21, 1901	20	38	Dec. 22, 1916	32	26
Feb. 17, 1903	26	26	Feb. 5, 1917	20	28
Dec. 15, 1904	20	38	Jan. 7, 1918	20	36
Jan. 26, 1905	20	28	Jan. 12, 1918	28	18
Dec. 13, 1909	22	38	Jan. 18, 1918	20	38
Dec. 2, 1910	20	42	Dec. 11, 1919	28	38
Jan. 5, 1912	20	40	Feb. 21, 1921	22	40
Jan. 9, 1912	22	32	Jan. 8, 1924	20	40
Dec. 11, 1914	20	38	Dec. 23, 1925	20	34

[1] Greatest rises in temperature, 7 a. m. to 7 a. m., in winter, 1901 to 1925, inclusive All rises of 20° or more listed. Telegraphic temperatures used—i. e., all readings to nearest even number.

Weather maps are available for 13 of the above dates. From these a composite chart has been prepared showing the distribution of pressure at the beginning of the 24-hour period during which the temperature rose 20° or more. The high-pressure area which advanced southeastward with the preceding cold wave is shown over the

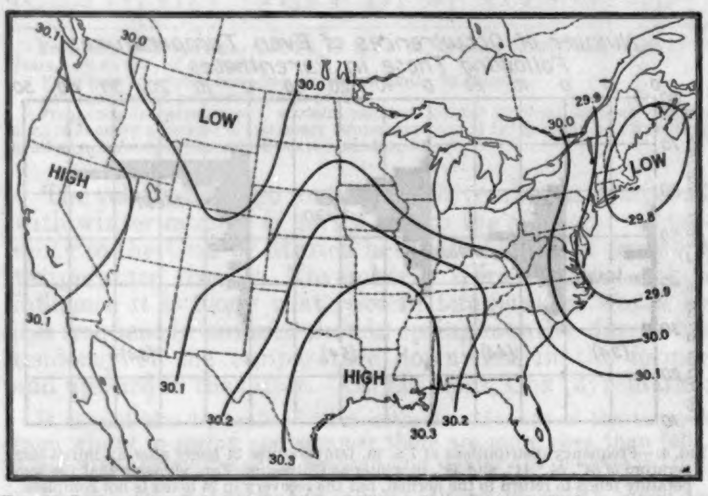

FIG. 5.—Barometric pressure at 7 a. m. preceding a rise in 24 hours of 20°, or more; composite of 13 pressure maps

middle and west Gulf region, with maximum pressure over southeastern Texas. The cyclonic depression appears in the far Northwest with minimum pressure at Helena, Mont. See Figure 5.

Temperature changes taking place in the preceding 24 hours are shown in Figure 6. This is a composite temperature change chart for 11 of the 13 cases grouped in Figure 5. Two maps were missing, due to the preceding day being a holiday, when no station map was drawn. The maximum temperature rise in the preceding 24 hours took place at Helena, Mont., 10°. The area of rising temperature extends southeastward into the northwestern portion of Texas. During this interval the temperature had continued to fall slowly at Galveston.

There can be no doubt, then, that the warm wave progresses southeastward from the same point as the cold wave. The one is attended by a flow of air from high to low latitudes and by atmospheric conditions which promote loss of heat through radiation, while the other is attended by a flow of air from lower to higher latitudes and by conditions which favor retention of the heat received through solar radiation.

Pressure indications.—It seems impossible to define with as great accuracy the pressure gradients favorable for a marked rise in temperature at Galveston in winter as is true of severe cold waves. The cold wave results from the transportation of air southward over considerable distances and the processes resulting in loss of heat are necessarily operative over a relatively long period of time. The source of warm air is, by contrast, near at hand. The temperature of the Gulf of Mexico is probably affected comparatively little at some distance from the shore, and immediately the wind is on-shore the temperature begins to rise. Slight pressure variations sometimes cause a shift of wind and a temperature rise that is quite local, the changes at Galveston frequently being out of harmony with those on the lower Texas coast. Low pressure in the middle or northern Rockies or the northern plains is, however, an essential. In the 94 cases of temperature rises exceeding the stationary limit in winter for which weather maps are available out of a total of 168 exceptions to this rule were rare. There were no instances of temperature rises exceeding the stationary limit when depressions were centered over the southern portions of New Mexico or Arizona, or in California or western Nevada, except when poorly defined and accompanied by well-defined depressions to the northward.

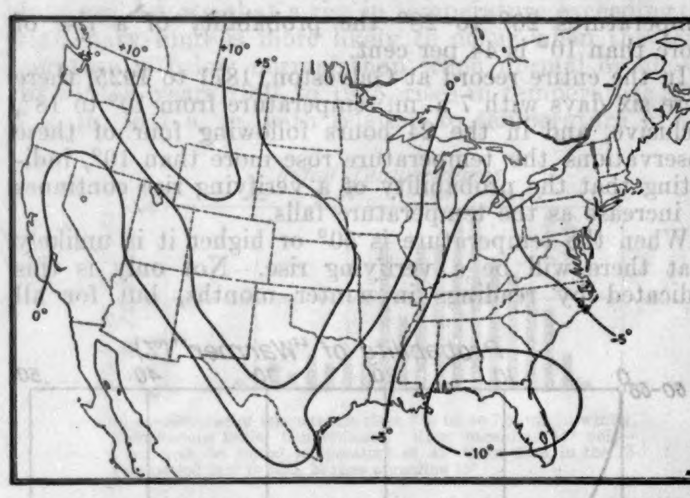

FIG. 6.—Average 24-hour temperature change, composite of 11 maps, during period immediately preceding 24 hours in which temperature at Galveston rises 20° or more

High pressure over the lower Mississippi Valley States and eastern and southern Texas is likewise an essential. The temperature must be below the normal, which condition requires the movement of at least relatively high pressure to that region. In 70 per cent of all cases the center of maximum pressure overlies that region, and when the center is over eastern or southern Texas or Louisiana and the temperature is below normal a rise is assured.

In more than 90 per cent of temperature rises exceeding the stationary limit, the center of maximum pressure had reached a line from Chicago to Del Rio. The farther northward on this line the center of the high crosses the less is the probability that the temperature will rise. HIGHS moving over northern sections produce smaller temperature changes and afford greater opportunity for the development of low pressure in the southwest, which is likely to result in continued cold weather.

The locations of high and low pressure areas in the 94 cases of temperature rise in winter are shown in Figure 7. The HIGH positions are indicated by dots, the LOWS by crosses. In nearly all instances of high pressure far to the north or east, there was an extension of the area southwestward into the lower Mississippi Valley or west Gulf region.

There is slow recovery from the cold wave when the cold extends to the west Gulf coast, but the center of maximum pressure remains in the North; when the HIGH moves slowly; when relatively high pressure persists over the northern Rocky Mountain region and when the succeeding LOW moves eastward near the southwestern border.

The temperature begins to rise within 24 hours after the center of the HIGH reaches a line joining Chicago and Del Rio, other conditions being favorable.

There is rapid recovery when the center of the high pressure area moves to southern districts and the succeeding LOW appears over the middle or northern Rockies or the northern plains.

Although the cold wave is attended by strong winds and in this latitude extreme cold is attained largely by importation of air from the northward, the warm wave is rarely attended by more than moderate winds. The highest wind recorded at the end of the 24-hour period

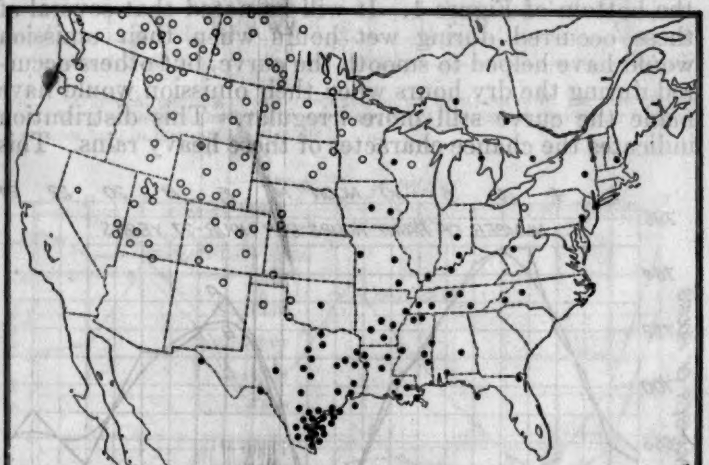

FIG. 7.—Positions of HIGHS and LOWS at 7 a. m. preceding 24-hour rise of more than 10° in winter—94 cases. Positions of HIGHS marked by dots; positions of LOWS shown by crosses

in which temperature rises of 20° or more occurred was 20 miles per hour. The average movement at 7 a. m. following the rise was 13 miles per hour.

Weather maps available for 12 cases in which the temperature was at or below 32° and in the ensuing 24 hours remained stationary or rose only 2° to 4°, were used to form the composite barometric chart in Figure 8. The conditions which are here unfavorable for a marked rise in temperature are: Location of the high-pressure crest slightly west of a line joining Chicago and Del Rio, maximum pressure at Oklahoma City; the location of the succeeding low-pressure area in the southwest, minimum pressure at El Paso; persistent high pressure over the northern Rocky Mountain region.

CONCLUSIONS

1. A temperature rise exceeding the stationary limit will not occur in any month unless the 7 a. m. temperature is below the normal 24-hour mean for that day.

2. Temperature rises are more frequent in autumn than in spring.

3. The lower the temperature the greater is the probability that it will rise, the percentage becoming approximately 50 when the temperature is 20°.

4. The "warm wave" advances from the same position as the cold wave and the low appears over the western portion of North Dakota and Montana, advancing southeastward.

5. The temperature begins to rise within 24 hours of the crossing of the HIGH center over a line joining Chicago and Del Rio, other conditions being favorable.

6. The recovery is rapid when the HIGH is broad in the south and narrow in the north, with the succeeding LOW in the northern Rockies or thereabouts.

7. Recovery is slow when the HIGH is broad in the north and narrow in the south and the LOW follows the southwestern border.

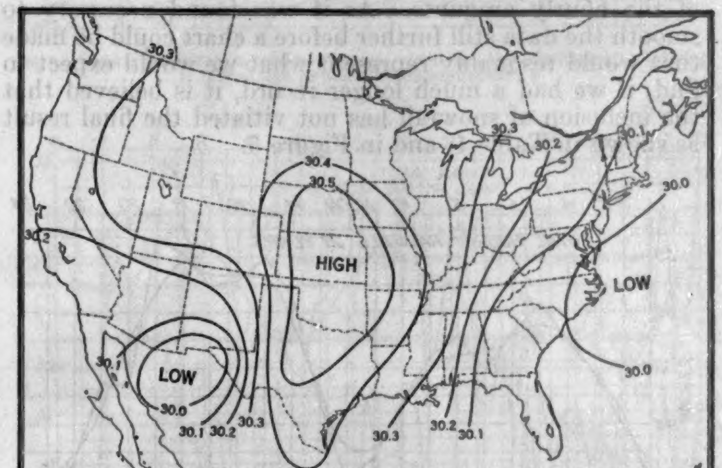

FIG. 8.—Composite of 12 pressure maps. Temperature at Galveston 32°, or below at 7 a. m. and rise in succeeding 24 hours 2° to 4° or stationary

8. When the center of high pressure overlies eastern or southern Texas or Louisiana and there is a well-defined LOW in the northwest, the temperature will rise rapidly if much below the normal.

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DISTRIBUTION OF RAINFALL AT KNOXVILLE, TENN., BY HOURS, WEEKS, AND MONTHS OF FOUR WEEKS

By J. F. Voorhees

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The basis for this study is the hourly precipitation, including snowfall, for 27 years, 1898-1924 inclusive, as recorded at Knoxville, Tenn.

It seemed desirable to include the snowfall in order that the weekly values might be as accurate as possible, as the snowfall amounted on the average to between 1 and 2 per cent of the annual precipitation.

The hourly values were pretty carefully estimated for the daylight hours, and when such an estimate could not be made the total for any known period was prorated evenly among the several hours. The only appreciable effect of including snowfall would be a slight smoothing of the hourly amounts. As it was found necessary to smooth the data still further before a chart could be made that would resonably represent what we would expect to find, if we had a much longer record, it is believed that the inclusion of snowfall has not vitiated the final result as shown in Table 1, and in Figure 5.

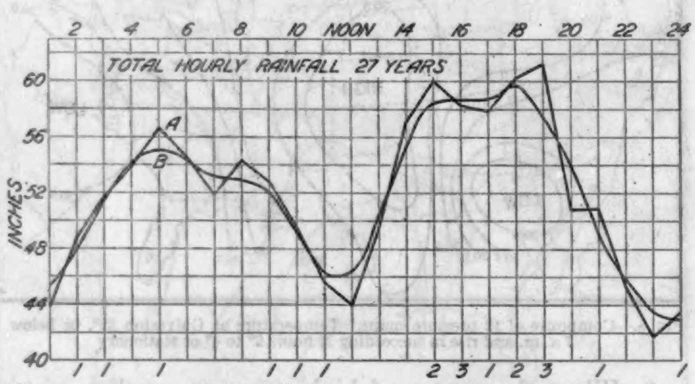

Fig. 1.—Total hourly precipitation in 27 years. Curve A, actual precipitation; curve B, smoothed curve. Figures at bottom, number of times with an inch or more, in 27 years

The object of the study was twofold. The first objective was to get some definite information about the rate of rainfall through the day and through the year, that would be of practical value in answering questions about rainfall insurance. The second objective was to make a comparison between our present calendar of 12 unequal months and the proposed calendar of 13 months of four weeks each, as a basis for studies of this kind. In this study February 29 and December 31 were ignored entirely. The data considered were total rainfall and the number of hours in which there was rain.

The rainfall for each hour of January first for 27 years was entered on one sheet and totals obtained for each hour. A similar sheet was made for each of the other days of the year, or 364 in all. The totals from these sheets were copied in groups of seven and added, giving weekly totals for each hour of the day. These in turn were grouped in fours, giving 13 monthly totals, and the sum of these gave the annual total for each hour of the day for the 27 years.

The number of hours on which rain occurred was treated in exactly the same way. These sheets were also added horizontally as a check and to obtain weekly and monthly values.

We will discuss first the hourly values and later the values for the week and the month.

The total rainfall per hour for the 24 hours of the day for 27 years is shown in Figure 1, by curve A. When it is considered that the record covers 9,828 days, and that of this number rain fell on about 700 on the average for each hour of the day, we may feel that this line represents the real distribution pretty accurately. But, on the other hand, we must remember that occasionally there is a rainfall of more than an inch in one hour, and that these heavy rains are comparatively few and very unevenly distributed. There were 19 hours during the 27 years in which 1 inch or more of precipitation was measured. These hours are indicated by the numbers at the bottom of Figure 1. It will be noted that several of these occurred during wet hours when their omission would have helped to smooth the curve, but others occurred during the dry hours when their omission would have made the curve still more irregular. This distribution indicates the chance character of these heavy rains. This

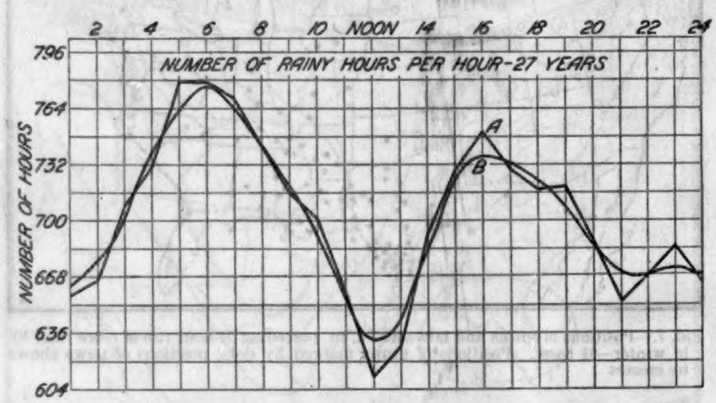

Fig. 2.—Number of hours with precipitation for each hour of the day in 27 years. Curve A, actual number of hours; curve B, smoothed curve

being the case it seemed proper to smooth the curve somewhat and the formula $\frac{1+2+3}{3}=2$, was used and the resulting curve is represented in Figure 1 by curve B. This probably represents as nearly as possible the average distribution of rainfall through the 24 hours of the day at this station.

It may be of interest to note here that the rainfall for the 12 hours from 6 a. m. to 6 p. m. is 51.5 per cent of the total for the 24 hours.

Figure 2, shows the total number of hours for each of the 24 hours of the day in which precipitation occurred. Curve A represents the actual number of hours and curve B the same data after applying the formula $\frac{1+2+3}{3}=2$. It is believed that here as in Figure 1, the minor variations are subject enough to chance to warrant this amount of smoothing.

The curves for total precipitation and duration are quite similar in a general way, but differ somewhat in details. The primary maximum for duration is in the morning and the primary minimum at noon, while the primary rainfall maximum is in the afternoon and the lowest minimum about midnight.

Dividing the total rainfall by the number of hours, the rate or average amount of rain per rainy hour was ob-

tained. Figure 3, represents the smoothed values of rainfall and number of rainy hours as percentages of their respective totals, and also the rate per hour in thousandths of an inch. This rate shows a rapid increase shortly after

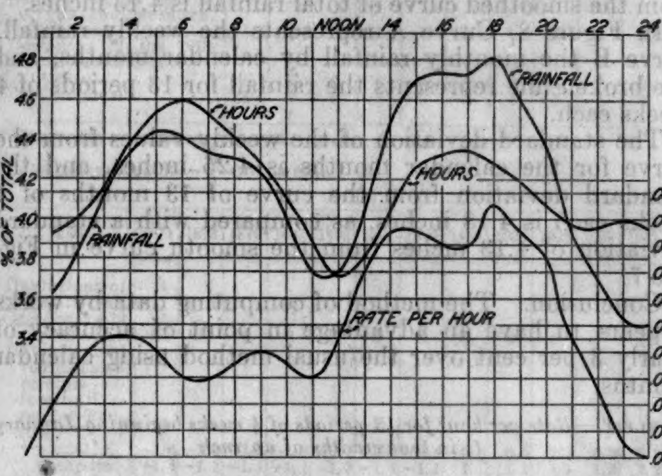

FIG. 3.—Curve A, per cent of total precipitation per hour; curve B, per cent of total number of hours with precipitation per hour; curve C, equals A divided by B, equals rate per hour in thousandths of an inch

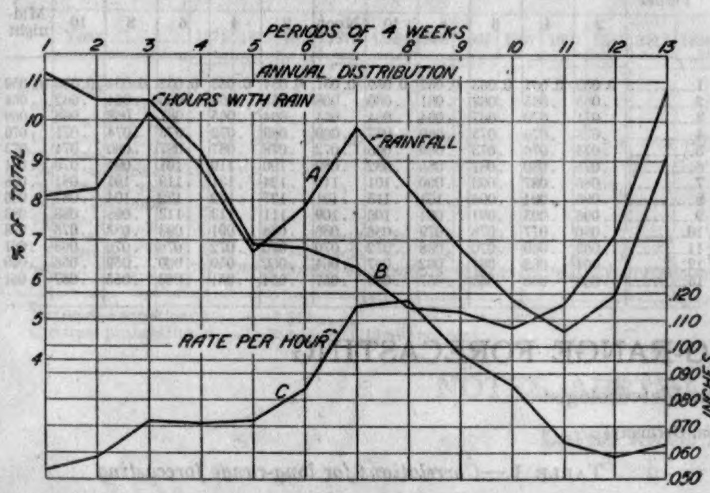

FIG. 4.—Annual distribution of precipitation in periods of four weeks. Curve A, per cent of total precipitation in each period; curve B, per cent of total number of hours with precipitation in each period; curve C, equals A divided by B, equals rate per hour in thousandths of an inch

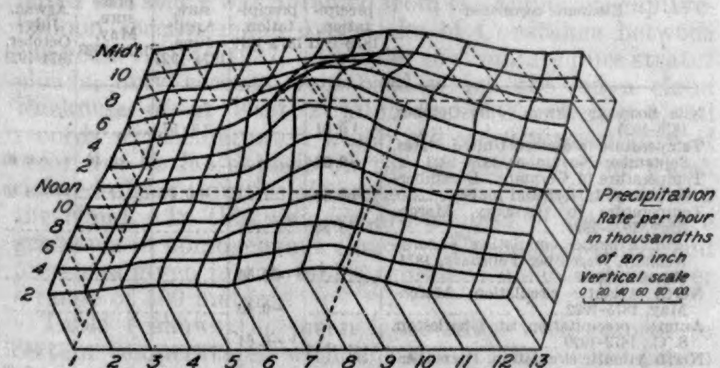

FIG. 5.—Graphic representation of rate per hour through the year in thousandths of an inch, from Table 1

midnight and another at noon followed by a very rapid fall from 6 p. m. to midnight.

In Figure 4, we have three curves representing the monthly per cent of total rainfall and rainy hours, and the rate per hour for each month. We are using here 13 months of 4 weeks each. It will be seen that the high rainfall during the winter and early spring is produced by a large number of hours with a low rate per hour,

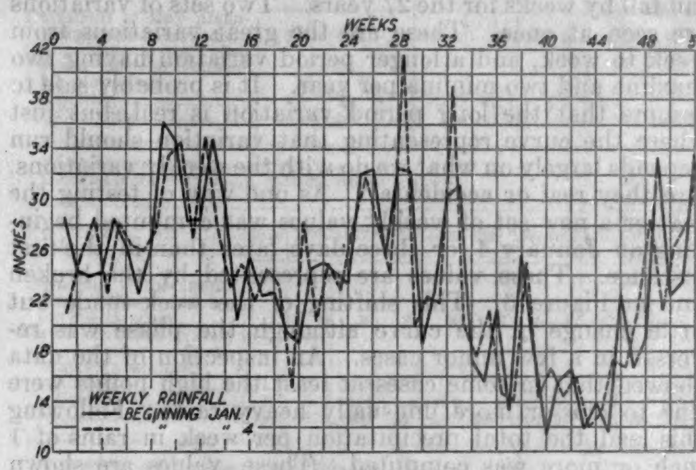

FIG. 6.—Weekly precipitation, total for 27 years. Solid line, 52 weeks beginning January 1; broken line, 52 weeks beginning January 4

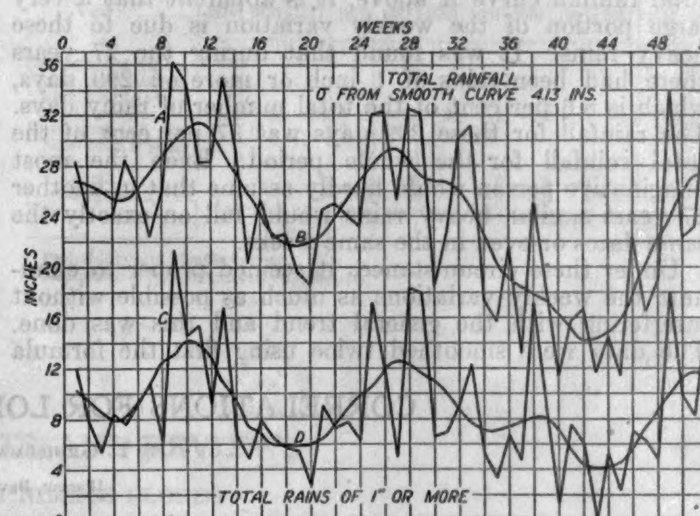

FIG. 7.—Precipitation. Curve A, total weekly; curve B, equals, curve A, smoothed; standard deviation of A from B is 4.13 inches; curve C, total weekly in rains of 1 inch or more; curve D, equals curve C, smoothed

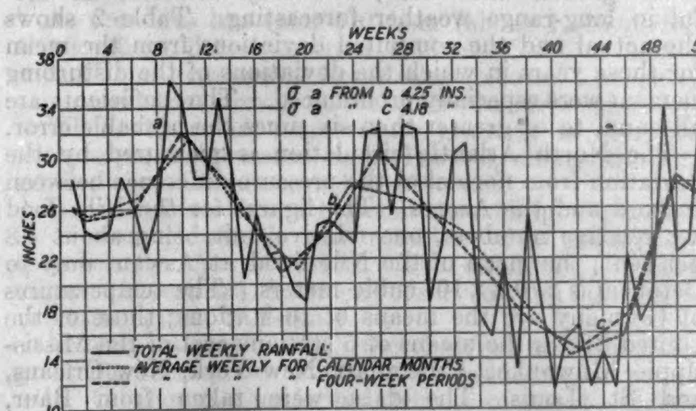

FIG. 8.—Precipitation. Curve A, total weekly; curve B, average weekly for calendar months; curve C, average weekly for periods of four weeks; standard deviation of A from B is 4.25 inches; standard deviation of A from C is 4.18 inches

while the summer maximum is due to a higher rate in a fewer number of hours.

Figure 5, is an attempt to show graphically the rate per hour through the day and through the year as found in Table 1.

For the comparison between the present calendar and the proposed 13-month calendar we will begin with the weekly values. The solid line in Figure 6 gives the total rainfall by weeks for the 27 years. Two sets of variations are seen at once. These are the great variations from week to week, and a longer period variation having two maxima and two minima per year. It is probably safe to assume that the long period variation is real, but just where the curve representing that variation should run depends largely on what we do with the weekly variations. Are they real or accidental? As one way of testing the matter a new set of weekly values was computed beginning on January 4, or three days later than in the first instance. These values are represented by the broken line in Figure 6. This shifting of the week made but little change in the curve although the phase was reversed in a few minor cases. An inspection of the data showed that in some cases at least the high points were due to one or more unusually heavy rains. Following this lead the total precipitation per week in rains of 1 inch or more was computed. These values are shown by curve C in Figure 7. Comparing this curve with the total rainfall curve A above, it is apparent that a very large portion of the weekly variation is due to these heavy rains. It was found that during the 27 years there had been rains of 1 inch or more on 299 days, which is 8.6 per cent of the total number of rainy days. The rainfall for these 299 days was 37 per cent of the total rainfall for the whole period. Even the most imaginative person would hardly assume that in another 27 years similar heavy rains would fall on exactly the same dates or even in the same weeks.

Under these circumstances it seemed proper to eliminate the weekly variations as much as possible without interfering with the general trend and this was done. The data were smoothed twice using first the formula $\frac{1+2+3+4+5}{5}=3$ and then the formula $\frac{1+2+3}{3}=2$. The curves B and D in Figure 7, represent the smoothed values. The standard deviation of the weekly values from the smoothed curve of total rainfall is 4.13 inches.

In Figure 8, Curve A represents the weekly rainfall, curve B the monthly rainfall by calendar months, and the broken line represents the rainfall for 13 periods of 4 weeks each.

The standard deviation of the weekly values from the curve for the calendar months is 4.25 inches, and the standard deviation from the curve of 13 months of 4 weeks each is 4.18 inches, as compared with a standard deviation of 4.13 inches from the smooth curve in Figure 7.

Conclusion. The method of computing data by weeks appears to have an advantage in point of accuracy of nearly 3 per cent over the usual method using calendar months.

TABLE 1.—*Rate per hour for 13 periods of 4 weeks beginning January 1, in thousandths of an inch*

Period	A. M.						P. M.					
	2	4	6	8	10	Noon	2	4	6	8	10	Midnight
1	0.062	0.064	0.063	0.062	0.059	0.057	0.054	0.053	0.052	0.054	0.056	0.059
2	.065	.065	.063	.061	.060	.058	.055	.058	.060	.064	.062	.064
3	.071	.070	.067	.064	.064	.064	.064	.065	.067	.068	.068	.069
4	.073	.076	.073	.069	.067	.069	.069	.072	.073	.074	.071	.070
5	.074	.076	.073	.069	.065	.072	.078	.087	.087	.080	.074	.073
6	.075	.080	.087	.085	.082	.089	.100	.110	.101	.091	.079	.074
7	.086	.087	.093	.090	.101	.110	.124	.131	.119	.101	.081	.078
8	.095	.094	.096	.101	.115	.121	.127	.132	.122	.104	.087	.086
9	.096	.093	.091	.091	.106	.109	.111	.113	.113	.098	.088	.083
10	.080	.077	.078	.079	.086	.086	.088	.091	.093	.083	.076	.073
11	.069	.069	.070	.068	.072	.070	.070	.072	.076	.070	.063	.061
12	.064	.062	.061	.062	.067	.064	.060	.059	.060	.059	.056	.060
13	.063	.060	.058	.057	.059	.057	.054	.051	.053	.055	.057	.061

CORRELATIONS FOR LONG-RANGE FORECASTING

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In Table 1 are listed 13 correlation coefficients, based on from 48 to 50 years' data. Of these, six are equal to or greater than 0.50, and may therefore be useful in long-range weather forecasting. Table 2 shows the actual and the computed deviations from the mean for those years in which the deviations of the disturbing element were especially pronounced. The coefficients are all equal to or greater than six times the probable error.

The North Atlantic circulation is measured by the deviation from normal of the pressure difference between Iceland and the Azores. The figures for the Nile flood are relative numbers, one relative unit being about 4.8 per cent; the mean of the Nile flood at Aswan, July to October, is 670.8×10^{8} cubic meters. The temperatures of Germany are the means of 10 stations; those of the United States the means of 5 stations east of the Mississippi—Milwaukee, Cincinnati, New York, New Orleans, and St. Louis. The data were taken from Baur, Grundlagen einer Vierteljahrestemperaturvorhersage für Deutschland (1926); Bliss, The Nile Flood and World Weather (1926); and Groissmayr, Die Nilflut und der Folgewinter in Deutschland (Met. Zeit., 1927).

TABLE 1.—*Correlations for long-range forecasting*

Elements correlated	Charleston precipitation, 1872-1921	Charleston precipitation, 1872-1919	Argentine pressure, April-June, 1874-1923	Argentine pressure, May, 1874-1923	Nile flood at Aswan, July-October, 1874-1923
Nile flood at Aswan, July-October, 1874-1923	[1] 0.61		0.57		
Temperature in eastern United States, September-November, 1874-1923	−0.28			[1] −0.46	−0.40
Temperature in Germany, December-February, 1874-75 and 1923-24	−0.38		−0.47		[1] −0.50
Temperature in Germany, March-May, 1875-1924	[1] −0.55				
North Atlantic circulation (Azores-Iceland), December-February, 1874-75 and 1921-22		[1 2] −0.66			
North Atlantic circulation, March-May, 1875-1922		−0.40			
Annual precipitation at Charleston, S. C., 1873-1920		[1] −0.64			
North Atlantic circulation, December-February, 1874-75 and 1923-24					−0.49

[1] The closest relations, so far as the author knows, ever found for these elements.
[2] Most important.

TABLE 2.—*Years of large departures of disturbing element*

Year	1874	1892	1894	1896	1902	1905	1909	1914	1915	1917	1919
Deviations ≧±1 mm. of Argentine pressure, April-June	1.3	2.4	1.5	1.5	−1.6	−1.0	1.3	−1.5	−1.4	1.2	−2.0
Deviations of the Nile flood, 3 months later:											
Actual	8	7	8	4	−6	−6	2	−3	−7	2	−3
Computed	4	7	5	5	−5	−3	4	−5	−4	4	−6

Regression on equation: $\Delta_{Nile}=3.1\,\Delta_{Press.}$

Contrast probability $=\frac{11}{11}=$ 100 per cent.

Year	1874	1878	1879	1887	1892	1894	1895	1899	1902	1905	1907	1913	1915
Deviations of the Nile flood ≧±6 or ≧±29 per cent	8	7	6	6	7	8	6	−6	−6	−6	−7	−12	−7
Deviations of German temperature following December-February° C.:													
Actual	−1.6	−1.0	−3.5	−1.8	−2.7	−3.1	−0.4	−0.5	0.6	1.2	0.2	0.9	2.8
Computed	−1.4	−1.3	−1.1	−1.1	−1.3	−1.4	−1.1	1.1	1.1	1.1	1.3	2.2	1.3

Regression equation: $\Delta_{Temp.}=-0.18\Delta_{Nile}$.
Contrast probability, $_{Nile}\geqq\pm6=12/13=92$ per cent.

Year	1874	1876	1877	1878	1885	1893	1901	1907	1908	1911	1917	1918
Deviations of the annual precipita- at Charleston ≧± 15 inches	15	30	30	29	20	23	−15	−16	−17	−16	−15	−17
Deviations of the North Atlantic circulation, 2½ years later, December-February:												
Actual	0	−10	−3	−17	−11	−2	6	8	2	3	10	1
Computed	−5	−10	−10	−10	−7	−8	5	5	6	5	5	6
Year	76/77	78/79	79/80	80/81	87/88	95/96	03/04	09/10	10/11	13/14	19/20	20/21

Regression equation: $\Delta_{circ.}=-0.34\Delta_{precip.}$
Contrast probability, $\Delta_{precip.}\geqq\pm15$, $=11/12=92$ per cent.

Year	1887	1892	1902	1906	1910	1915	1917	1919	1920
Deviations of May Argentine pressure ≧±2 mm	2.3	2.8	−2.3	−21.1	2.0	−3.1	3.7	−3.1	−2.1
Temperatures in east United States following September-November:									
Actual	−1.9	−2.1	1.9	1.0	−0.1	2.2	−3.4	1.7	1.4
Computed	−1.2	−1.4	1.2	1.1	−1.0	1.6	−1.9	1.6	1.1

Regression equation: $\Delta_{temp.}=-0.51\Delta_{press.}$
Contrast probability, $\Delta_{press.}\geqq$2mm., 100 per cent.

Year	1874	1876	1877	1878	1885	1893	1901	1907	1908	1911	1917	1918
Deviations of the annual precipitation at Charleston ≧± 15 inches	15	30	30	29	20	23	−15	−16	−17	−16	−15	−17
Deviations of temperature in Germany, March-May, 2¾ years later:												
Actual	−1.7	−1.6	0.3	−1.3	−1.5	−0.2	0.4	0.6	0.9	1.1	2.6	1.9
Computed	−0.7	−1.4	−1.4	−1.3	−0.9	−1.0	0.7	0.7	0.8	0.7	0.7	0.8
Year	1877	1879	1880	1881	1888	1896	1904	1910	1911	1914	1920	1921

Regression equation: $\Delta_{temp.}=-0.046\Delta_{precip.}$
Contrast probability, $\Delta_{precip.}\geqq\pm15$, 92 per cent.

Year	1874	1876	1877	1878	1885	1893	1901	1907	1908	1911	1917	1918
Deviations of the annual precipitation at Charleston ≧±15 inches	15	30	30	29	20	23	−15	−16	−17	−16	−15	−17
Deviations of the Nile flood 2 years later:												
Actual	4	7	6	2	6	6	0	2	−1	−12	−3	−3
Computed	3	7	7	6	4	5	−3	−4	−4	−4	−3	−4
Year	1876	1878	1879	1880	1887	1895	1903	1909	1910	1913	1919	1920

Probability = 10/12 = 83 per cent.
Regression of equation: $\Delta_{Nile}=0.22\Delta_{precip.}$

NOTES, ABSTRACTS, AND REVIEWS

LAPSE RATE IN NIMBUS CLOUDS

By W. PEPPLER

(Abstracted from Meteorologische Zeitschrift, May, 1928, by W. R. Stevens)

The observational material upon which the author has based this study was obtained from the numerous captive-balloon ascents made over Lake of Constance between the years 1910 to 1927. In order to eliminate pure stratus clouds, only ascents were used which showed a cloud thickness of at least 2 kilometers. Furthermore, all records were eliminated which indicated a possibility of error due to ice deposit on the meteorograph or which showed discontinuities of temperature or humidity within the cloud. In this way we are assured of temperature gradients in homogeneous clouds. The temperatures and pressures given in the tables represent mean values over a range of 500 meters.

Table 1 shows the mean lapse rates with respect to certain temperatures without taking into consideration either height or pressure. N indicates the number of observations.

Above 3° C. the lapse rate is about 0.57. Between +1° C. and −1° C. there is a depression to 0.51, and at lower temperatures there is an approximately linear decrease to 0.68 at −14° C.

Table 2 shows lapse rates in nimbus clouds with temperatures and pressures as arguments.

At pressures less than 620 mm. (about 1,500 meters) the gradient decreases from 0.58 at 6° C. to 0.52 at −2° C. and increases at lower temperatures. Much the same conditions prevail at the other pressures considered.

When the mean temperature gradient is computed with respect to pressure, as in Table 3, almost the same gradient prevails between 480–660 mm.

It is seen from Tables 1–3 that the computed gradients in nimbus clouds do not coincide with those which theoretically should prevail. The difference (observed minus theoretical) between observed and theoretical values are given in Table 4.

At temperatures of 3° C. the observed and theoretical gradients correspond; but at temperatures near zero to −10° C. there is a uniform difference of about −0.06.

Table 5 shows the difference at various temperatures divided into three intervals of pressure and indicates much the same as Table 4.

Table 6 gives the percentage frequency of various differences between observed and theoretical gradients.

Small negative deviations between zero and −0.08 are most frequent. The question which naturally arises is whether the differences between observed and com-

puted gradients are real and, if so, how they are to be explained.

The author lists four factors which may be responsible for the differences:

1. The vertical exchange of heat within the cloud through radiation. Since measurements are not available the order of magnitude is not known.
2. Absorption of solar radiation by the cloud, especially in the upper part.
3. The effect of precipitation which tends toward a diminution of the lapse rate. Even when no precipitation occurs the heavier drops sink and bring about an exchange of heat. This factor appears to be very important in decreasing the lapse rate.
4. Incomplete mixing of (*a*) air masses of different temperatures and (*b*) apparently homogeneous layers in which vertical motion and condensation has ceased.

The lapse rate was determined for three portions of each cloud and the following mean results obtained: Lower part, 0.58; central part, 0.60; upper part, 0.56. Theoretically we should expect a gradual increase with altitude. In this connection it may be of interest to quote from Suring in "Wissenschaftliche Luftfahrten":

> A relatively low lapse rate was found in the lower part of thick rain clouds above which was a layer approaching adiabatic—the principal condensation layer. Above the central portion, in spite of the sharply bounded surface, the clouds were so tenuous that sunshine penetrated far into them.

In the lower portion of a nimbus cloud there frequently exists a zone of mixing of different air masses, especially when the cloud lies directly above a surface of discontinuity, resulting in smaller lapse rate than would otherwise prevail.

The smaller lapse rate in the upper portion of the cloud seems to be a result of mixing of different air masses and the absorption of solar radiation. Since the upper portions of thick nimbus clouds usually consist of ice crystals, and since all the ascents were made during the day, the latter factor would be a very important one. It seems that at least 20 per cent of the total radiation would be absorbed by the cloud.

In conclusion the author brings attention to the following problems which need to be solved:

1. Temperature distribution in clouds, especially in regard to the difference between theory and observation, treated in this paper.
2. Vertical thermal structure of clouds; discontinuities which frequently occur in nimbus clouds, especially before and after precipitation within strata or as a result of convection.
3. Effect of radiation between cloud layers, especially in the upper portion and at the upper surface.
4. Distribution and magnitude of the factors of condensation; supersaturation and supercooling in clouds.
5. Atmospheric electricity in clouds, especially in case of manifold stratification, which would probably provide a key to the explanation of the sudden uniting of separate layers and the energetic condensation which ensues.
6. Measurement of temperature and humidity with the aspiration psychrometer in free balloons and at the same time with meteorographs in kites, captive balloons, or airplanes, especially at temperatures near zero, in order to determine whether the observations obtained by means of the meteorograph is correct. The importance of this question should be emphasized.

TABLE 1

T. (° C.)	10.0/6.1	6.0/4.1	4.0/2.1	2.0/0.1	0.0/1.9	−2.0/−3.9
dT./100	0.57	0.56	0.57	0.51	0.52	0.55
N	22	37	45	68	80	78
T	−4.0/−5.9	−6.0/−7.9	−8.0/−9.9	−10.0/−11.9	−12.0/−15.9	....
dT./100	0.58	0.60	0.64	0.67	0.68	....
N	65	57	32	25	18	....

TABLE 2

T. (° C.)	8.0/4.1	4.0/0.0	−0.1/−4.0	−4.1/−8.0	<−8.1
>620 mm	0.58	0.55	0.52	0.63	....
N	24	26	25	20	....
620–570 mm	0.57	.054	0.53	0.58	0.64
N	28	61	73	58	33
<570 mm	....	0.54	0.54	0.57	0.67
N	....	28	53	40	33

TABLE 3

Pressure (mm.)	480/510	511/540	541/570	571/600	601/630	631/660
dT./100	0.56	0.57	0.57	0.57	0.57	0.57
N	16	35	101	126	158	80

TABLE 4

T. (° C.)	10.0/6.1	6.0/4.1	4.0/2.1	2.0/0.1	0.0/−1.9
Difference	+0.03	−0.01	+0.01	−0.06	−0.07
N	22	37	45	67	81
T. (° C.)	−2.0/−3.9	−4.0/−5.9	−6.0/−7.9	−8.0/−9.9	≦−10.0
Difference	−0.07	−0.07	−0.07	−0.06	−0.05
N	78	65	57	32	43

TABLE 5

T. (° C.)	8.0/4.1	4.0/0.0	−0.1/−4.0	−4.1/−8.0	<−8.1
>620 mm	+0.01	−0.02	−0.10	−0.04	....
N	25	25	25	24	....
620–570 mm	+0.01	−0.02	−0.08	−0.07	−0.09
N	26	63	75	61	34
<570 mm	....	−0.03	−0.04	−0.08	−0.04
N	....	27	55	41	33

TABLE 6

Difference	+0.25/0.20	+0.19/0.15	+0.14/0.10	+0.09/0.05	+0.04/0.00
Per cent	1.0	2.3	6.6	9.8	13.2
Difference	−0.01/−0.05	−0.06/−0.10	−0.11/−0.15	−0.16/−0.20	....
Per cent	22.1	19.2	9.8	7.4	....
Difference	−0.21/−0.25	−0.26/−0.30	−0.31/−0.35	<−0.36	....
Per cent	4.7	2.3	0.9	0.7	....

An engineering classic.[1]—In a paper recently presented to the American Society of Civil Engineers, Profs. S. M. Woodward and F. A. Nagler have given the profession an engineering classic. Their paper is an analysis of fact so keen and at the same time so fair and judicious in both method and conclusion as to constitute a model of engineering induction. If these qualities give it an exceptional fascination to the inquiring mind, its strength of appeal is further heightened by the subject, which is one of the most perplexing factors surrounding floods and flood protection.

Serious attention to the destructive power of floods and how to guard against them has been long delayed. Little real engineering study was given to the matter until about twenty years ago, and not until the phenomenal rainfall that deluged the belt of country north of the Ohio River in 1913 did flood protection gain a place in the first rank of engineering problems. Even after this period, and in spite of a steady repetition of flood disasters, the public remained apathetic except

[1] Reprinted from Engineering News-Record July 5, 1928.

locally in the wake of great destruction, as at Pueblo. The great flood in the lower Mississippi in 1927 finally translated the problem into such huge proportions as to assure the subject permanent attention.

There are ordinarily long intervals between great floods, and since all American river-flow records are short there is a tendency for higher floods than any on record to make their appearance. Further, land culture and river-bank settlement modify stream flow. Under these conditions of complication, various men have been inclined to single out either one or another factor in the situation as decisive, and develop correspondingly individual theories of flood prevention.

Thus, deforestation was widely blamed as a cause of increased flood height. Others saw the chief source of trouble in the extension of land cultivation and the coincident reduction in soil cover. Soil erosion and flood incidence were correlated by others, who therefore advocated contour plowing. And, finally, land drainage was charged by many with a material contribution to floods. Following the Mississippi Valley flood of last year in particular, drainage was brought in to the argument and by implication a distinct share in the destruction wrought in the lower valley was assigned to those progressive agricultural States along the upper and middle course of the river which had developed drainage most largely. It is this question of the influence of drainage upon floods that the paper in question finally places on a basis of definite proof by fact. Unreasonable as the argument of drainage influence was—since the increased soil-reservoir storage resulting from the lowering of ground-water level due to drainage could only operate to retard run-off—it yet was sufficiently persistent and influential to have a seriously confusing effect on proper understanding of the flood problem. By laying the ghost of drainage, Professors Woodward and Nagler thus contribute greatly to the advance of flood study.

The method which they adopted in their analysis is intensely instructive. Briefly, they first studied the records of the development of land drainage in the upper Mississippi Valley, and found two large regions in which drainage has been so far developed as to affect a large fraction of the potential run-off. The beginning of drainage development, however, was considerably later in the more westerly of the two regions, so that substantially the whole development of drainage here occurred within the past 20 years. On two large rivers which drain this region, careful flow observations have been made since before drainage began. Accordingly this region, in central and northern Iowa, was selected for the study.

Prior to 1905, organized drainage work in this region was not very extensive, due to lack of suitable legislative authorization. The great bulk of the work was comprised in the 10-year interval, 1907–1917. A 4-year record of stream flow, 1903–1906, was accordingly taken as representative of flood relations prior to drainage, while the 6-year period 1918–1923 was taken to represent conditions with drainage. The total contributing areas above the several stream-gauging points range from 3,000 to 14,000 square miles, and the drained fractions range from more than one-third to substantially the whole of the area, for the later period of stream-flow comparison. The case thus selected for the study is remarkably well adapted to the purposes of the inquiry; nowhere else in the country could equally favorable conditions for the comparison be found, as the authors well emphasize.

Since rainfall conditions and flood probabilities in the two selected flood-flow periods were in all likelihood quite dissimilar, the investigators made their analysis by studying particular storms and their run-off. Preliminary comparisons of monthly run-off with monthly precipitation during the spring months showed rather widely scattering results, but the scatter areas for the predrainage and post-drainage periods coincided fairly well. Next, every storm that produced a flood exceeding a certain minimum was analyzed; again the plotted points showing relation of flood run-off to precipitation fitted closely together for the two periods. Thus the anlysis almost incontrovertibly proved that drainage has caused no measurable difference in total run-off. The same thing was found for peak rate of flow, the results again grouping closely enough to furnish a definite test of the question at issue. Thus drainage also has not increase the peak flow of floods.

Though these results afforded conclusive proof, the authors carried their analysis still farther by applying a more delicate test of change in the water-retentive power of the stream basin due to drainage. This test was found in a comparison of the rate of decrease ot flow after the flood peak, which decrease would obviously be more rapid for the less retentive condition; that is, if drainage caused the water to discharge into the stream more rapidly, the flood wave should ebb away more rapidly after its peak than it did in the undrained condition of the land. But the comparison showed no difference, and it could only be concluded that the watershed was fully as retentive after drainage as before.

In demonstrating that land drainage has had no detectible effect upon flood flow in rivers, the authors build up their proof from data selected with the utmost care to get a fair comparison, and their analysis utilizes these data with the highest degree of ingenuity and incisiveness. Their findings, as we said above, will be of distinct assistance in fostering sound engineering thought on flood protection. Even beyond its value in this respect, however, their studies will long stand as a classic example of scientific engineering analysis.

World Weather, Part III, G. T. Walker and E. W. Bliss [1] *(Roy. Met'l. Soc. Mem. 2, 17, pp. 97–134, April, 1928.*—The present paper forms a continuation of two papers in the Indian Meteorological Memoirs (vol. 24, parts 4 and 9), and extends the tables of relations between 20 centers of action to those between 32 centers. Of the new centers 9 deal with temperatures, 2 with pressures, 1 with Nile floods, 1 with ice in the Barents Sea, while 1 old center is abolished. The relationships between the centers may be expressed most simply in terms of three systems, the Southern oscillation, the North Atlantic oscillation, and the North Pacific oscillation. The nature of the relations with the oscillations are tabulated, the degree of closeness being shown numerically and the signs + or − used to indicate growth with an increase or decrease of the atmospheric circulation. Of the new centers the temperatures of Batavia and Samoa and the Nile floods are very important in the Southern oscillation, Samoa having in all in the four quarters 37 coefficients of 0.6 or over, Batavia temperature 78 "significant" coefficients during the year and the Nile 31 in one season. The oscillations are not regarded as controlled by sun spots numbers but as systematic swayings of interconnected world conditions which are slightly intensified or checked by solar conditions.—*R. S. R.*

New rainfall and temperature map of North Carolina.—A large shaded map of annual rainfall with annual isotherms and also drainage basins and gauging stations printed on it has been prepared by Charles E. Ray under the supervision of Thorndike Saville and published by the

[1] Reprinted from Science Abstracts, Aug. 25, 1928.

water resources division of the North Carolina department of conservation and development. It constitutes Plate I of Economic Paper 61 (1928). While the features of the rainfall do not stand out clearly owing to the other items on the map, the heavy rainfall of over 80 inches on the southwestern highlands and the moderate rainfall of under 40 inches in the valley in the rain shadow to the north are in evidence. In the east the rainfall is moderately heavy, 50 to 55 inches being most prominent, though less than 50 and even under 45 occupy belts inland and on the southern portion of the coast. The mean annual temperatures range from under 50 in the extreme northwest to over 63 in the southeast. The bases for these isohyets and isotherms are the full records from the climatological stations in the State. A more comprehensive study of the rainfall, including due consideration of homogeneity of the years of record, is in preparation.—*C. F. B.*

Proposed meteorological service for East Africa.—Mr. Charles H. Albrecht, American consul at Nairobi, Colony of Kenya, Africa, communicates the following—

"The establishment of a meteorological service embracing British East African territories and Egypt and linking up with similar services in other parts of the world is foreshadowed in a memorandum which has been circulated to members of the Kenya Legislative Council. "Some of the benefits of the service, the cost of which would be met by the various territories concerned, would include a permanent survey of climatic conditions affecting human and crop disease, insect pests, the ascertainment of the relation of climate to reafforestation problems, rainfall forecasts, and the best routes for air services."

Meteorological summary for Chile, August, 1928 (by J. Bustos Navarrete, Observatorio del Salto, Santiago, Chile).—There was some increase in the activity of atmospheric circulation, especially in the second half of the month. The chief depressions were those of the 4th–6th, with rain north to Concepcion; 15th–16th, with rain north to Curico; 21st–24th, with scattered rains in central and southern regions; 25th–27th, with squally weather north to Valparaiso; and 29th–31st, with rain north to Arauco.

Periods of fine weather accompanied the high-pressure areas charted as follows: 1st–5th, 7th–12th, and 17th–22d.

Total precipitation for August: Santiago, 0.32 inch; Valdivia, 6.98 inches.—*Translated by W. W. R.*

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RECENT ADDITIONS

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SOLAR OBSERVATIONS

SOLAR AND SKY RADIATION MEASUREMENTS DURING SEPTEMBER, 1928

By HERBERT H. KIMBALL, Solar Radiation Investigations

For a description of instruments and exposures and an account of the method of obtaining and reducing the measurements, the reader is referred to the REVIEW for January, 1924, **52**:42; January, 1925, **53**:29, and July, 1925, **53**:318.

Table 1 shows that in general solar radiation intensities averaged close to normal values for September at all three stations.

Table 2 shows that the total radiation received on a horizontal surface directly from the sun and diffusely from the sky was above the September normal at Madison and Lincoln, and below at Washington.

Skylight polarization measurements made at Washington on four days give a mean of 52 per cent with a maximum of 55 per cent on the 26th. At Madison measurements made on 6 days give a mean of 66 per cent with a maximum of 73 per cent on the 4th. These are below the corresponding averages for September at Washington, but close to normal at Madison.

TABLE 1.—*Solar radiation intensities during September, 1928*

[Gram-calories per minute per square centimeter of normal surface]

Date	Sun's zenith distance										
	8 a.m.	78.7°	75.7°	70.7°	60.0°	0.0°	60.0°	70.7°	75.7°	78.7°	Noon
	75th mer. time	Air mass A. M.					Air mass P. M.				Local mean solar time
	e.	5.0	4.0	3.0	2.0	*1.0	2.0	3.0	4.0	5.0	e.
Washington, D. C.											
	mm.	cal.	cal.	cal.	cal.	cal.	cal.	cal.	cal.	cal.	mm.
Sept. 10	14.10	0.21	0.30	0.41	0.68	0.89	0.72				15.11
Sept. 13	18.59					1.33					15.11
Sept. 14	12.24	0.76	0.91	1.02	1.16	1.47	1.13	0.93			10.59
Sept. 22	10.97				1.21	1.55					5.79
Sept. 24	6.76	0.71	0.79	0.92	1.17						4.75
Sept. 26	4.95	0.83	0.94	1.06	1.19	1.44					4.95
Sept. 27	6.76				1.24						6.27
Sept. 28	6.02	0.69	0.81	0.94	1.16	1.45					4.57
Means		0.64	0.75	0.87	1.12	1.36	(0.92)	(0.93)			
Departures		−0.05	±0.00	±0.00	+0.07	+0.03	−0.13	+0.08			
Madison, Wis.											
Sept. 4	7.29			1.05	1.22	1.44					7.57
Sept. 6	8.18				1.07	1.26					7.57
Sept. 7	8.81				0.87	1.11					9.83
Sept. 19	7.57				1.14		1.22				7.29
Sept. 20	8.48					1.35					7.87
Sept. 21	8.48					1.50					6.76
Sept. 22	5.79		0.99	1.12							6.76
Sept. 24	3.81				1.27						3.45
Sept. 27	3.81	0.97	1.04	1.13	1.29	1.50	1.28				4.75
Sept. 29	6.02				1.16	1.27	1.00				7.04
Means		(0.97)	(1.02)	1.10	1.15	1.35	1.17				
Departures		+0.08	+0.11	+0.06	−0.02	−0.03	+0.01				
Lincoln, Nebr.											
Sept. 3	6.27			1.14	1.26	1.59					5.79
Sept. 4	6.50						1.20				7.87
Sept. 5	9.14		0.83	0.98	1.16	1.39					10.59
Sept. 7	10.97		0.72	0.84	1.03	1.32		0.83	0.69	0.58	10.97
Sept. 8	10.59		0.73	0.87	1.06	1.36	1.05	0.88	0.74	0.64	14.10
Sept. 12	10.97		0.95	1.03	1.23	1.48					11.38
Sept. 15	8.18		0.94	1.05	1.20	1.46	1.18	0.97	0.80	0.72	6.50
Sept. 18	6.27						0.94	0.68	0.54		5.79
Sept. 21	6.02			1.09	1.28	1.45	1.23	1.14	1.02	0.91	5.16
Sept. 22	5.36		0.91	1.05	1.21		1.21	1.00	0.95	0.83	6.27
Sept. 24	5.16					1.33	1.24	1.08	0.94	0.82	5.16
Sept. 25	2.87					1.45	1.22	1.03	0.81	0.76	2.87
Sept. 27	4.37				1.12	1.39					3.81
Sept. 28	6.76						0.95				7.87
Sept. 29	5.36	0.87	0.94	1.09	1.29	1.50	1.29	1.04	0.97	0.77	3.81
Means		(0.87)	0.84	1.00	1.17	1.42	1.15	0.97	0.83	0.75	
Departures		+0.11	−0.03	−0.01	−0.02	+0.02	±0.00	−0.01	±0.00	+0.02	

* Extrapolated.

TABLE 2.—*Solar and sky radiation received on a horizontal surface*

[Gram-calories per square centimeter of horizontal surface]

Week beginning—	Average daily radiation						Average daily departure from normal		
	Washington	Madison	Lincoln	Chicago	New York	Twin Falls	Washington	Madison	Lincoln
1928	cal.	cal.	cal.	cal.	cal.	cal.	cal.	cal.	cal.
Sept. 3	268	451	503	370	272	600	−108	+82	+66
Sept. 10	307	292	456	322	283	536	+22	−50	+51
Sept. 17	249	411	396	348	251	586	−99	+77	+12
Sept. 24	278	367	392	303	242	546	−58	+76	+49
Excess or deficiency since first of year on Sept. 30							−2,501	+976	−520

POSITIONS AND AREAS OF SUN SPOTS

[Communicated by Capt. C. S. Freeman, Superintendent U. S. Naval Observatory. Data furnished by Naval Observatory, in cooperation with Harvard, Yerkes, and Mount Wilson Observatories. The differences of longitude are measured from central meridian, positive west. The north latitudes are plus. Areas are corrected for foreshortening and are expressed in millionths of sun's visible hemisphere. The total area, including spots and groups, is given for each day in the last column]

Date	Eastern standard civil time	Heliographic Diff. long.	Heliographic Longitude	Heliographic Latitude	Area Spot	Area Group	Total area for each day
1928	H. m.	°	°	°			
Sept. 1 (Naval Observatory).	11 54	−70.5	8.1	−15.0	77		
		−52.5	26.1	−16.0	6		
		−39.5	39.1	+20.0	12		
		−33.0	45.6	+8.0	93		
		+27.5	106.1	+5.5	46		
		+51.0	129.6	+16.0		185	
		+64.0	142.6	+14.5	154		
		+71.0	149.6	−21.0	62		635
Sept. 2 (Naval Observatory).	13 27	−57.0	7.5	−14.5	77		
		−38.0	26.5	−16.0	25		
		−18.5	46.0	+8.0	77		
		+32.5	97.0	−8.5		46	
		+41.5	106.0	+5.5	37		
		+43.5	108.0	−14.0	9		
		+67.0	131.5	+16.0		185	
		+79.5	144.0	+14.0	154		610
Sept. 3 (Naval Observatory).	12 2	−75.0	337.1	−16.5	31		
		−71.0	341.1	−17.0	62		
		−44.5	7.6	−13.5	56		
		−6.0	46.1	+7.5	77		
		+15.5	67.6	−2.0		46	
		+45.5	97.6	−8.5		93	
		+52.5	104.6	+5.5		31	
		+59.5	111.6	+12.5		62	
		+80.0	132.1	+15.5		154	612
Sept. 4 (Naval Observatory).	13 34	−61.0	337.0	−16.5	25		
		−56.0	342.0	−17.0	62		
		−29.5	8.5	−13.5	62		
		−3.0	35.0	+0.5	6		
		+8.0	46.0	+7.5	62		
		+28.5	66.5	−1.5		25	
		+33.0	71.0	−1.0		22	
		+59.0	97.0	−8.5		154	
		+67.0	105.0	+5.5	9		
		+73.0	111.0	+12.5		62	489
Sept. 5 (Mount Wilson)	13 30	−43.0	342.0	−19.0		27	
		−16.0	9.0	−15.0	67		
		+6.5	31.5	+19.0	4		
		+23.0	48.0	+7.0	76		
		+49.0	74.0	−2.0	16		
		+54.5	79.5	+8.0	6		
		+73.0	98.0	−8.0		30	226
Sept. 6 (Mount Wilson)	12 45	−79.0	293.1	+15.0		312	
		−30.0	342.1	−17.0		31	
		−3.0	9.1	−14.0	49		
		+18.0	30.1	+19.0		11	
		+36.0	48.1	+7.0		65	
		+63.0	75.1	−2.0	8		476
Sept. 7 (Harvard)	10 16	−63.0	297.0	+16.0	453		
		+10.0	10.0	−13.5	55		
		+49.5	49.5	+6.0	69		577
Sept. 8 (Naval Observatory).	11 5	−60.5	286.1	+13.5		185	
		−53.5	293.1	+13.5		463	
		−36.0	310.6	+8.5		77	
		−31.5	315.1	+8.0		123	
		−23.5	323.1	+12.5		15	
		−3.0	343.6	−17.5		22	
		+22.5	9.1	−14.5	46		
		+45.0	31.6	+17.5	6		
		+61.0	47.6	+6.0	123		1,060
Sept. 9 (Naval Observatory).	11 44	−47.0	286.0	+13.5		185	
		−39.0	294.0	+14.0		494	
		−22.5	310.5	+8.5		247	
		−16.5	316.5	+7.5		123	
		−11.0	322.0	+12.0		6	
		+11.0	344.0	−17.0	9		
		+36.0	9.0	−14.5	56		
		+60.5	33.5	+18.5		15	
		+75.0	48.0	+6.0	93		1,228

Positions and areas of sun spots—Continued

Date	Eastern standard civil time		Heliographic			Area		Total area for each day
			Diff. long.	Longi-tude	Lati-tude	Spot	Group	
1928	H.	m.	°	°	°			
Sept. 10 (Naval Observatory).	11	45	−30.0	289.8	+13.5		401	
			−24.5	295.3	+14.0		370	
			−11.0	308.8	+8.5	108		
			−7.5	312.3	+9.0		93	
			−2.5	317.3	+7.5	123		
			+49.5	9.3	−14.5	46		1,141
Sept. 11 (Naval Observatory).	11	48	−77.0	229.6	−11.0	309		
			−21.0	285.6	+13.0		93	
			−16.5	290.1	+13.5		494	
			−12.0	294.6	+15.0		247	
			−8.5	298.1	+12.5	123		
			+2.0	308.6	+8.5	139		
			+5.0	311.6	+9.0		93	
			+11.5	318.1	+6.0	139		
			+62.5	9.1	−14.5	46		1,683
Sept. 12 (Naval Observatory).	11	45	−62.0	231.4	−11.0	247		
			−8.0	285.4	+13.5		93	
			−2.5	290.9	+13.5		401	
			+2.0	295.4	+14.5		278	
			+5.0	298.4	+13.0	108		
			+15.5	308.9	+8.5		139	
			+26.0	319.4	+6.0		93	
			+35.0	328.4	+12.5		15	
			+59.5	352.9	+10.0	31		
			+77.5	10.9	−14.5	46		1,451
Sept. 13 (Naval Observatory).	11	40	−49.0	231.2	−11.0	247		
			+10.0	290.2	+13.5		432	
			+15.0	295.2	+14.5	185		
			+18.0	298.2	+13.0	108		
			+28.5	308.7	+8.5		108	
			+40.0	320.2	+6.0	108		
			+73.0	353.2	+10.0	31		1,219
Sept. 14 (Naval Observatory).	11	54	−35.5	231.4	−11.0	185		
			+20.5	287.4	+15.0		93	
			+24.0	290.9	+13.5		278	
			+28.0	294.9	+14.5	216		
			+31.0	297.9	+13.5	216		
			+42.0	308.9	+8.5		93	
			+52.5	319.4	+7.0		123	1,204
Sept. 15 (Naval Observatory).	10	58	−22.0	232.2	−11.0		185	
			+38.0	292.2	+13.5		185	
			+41.5	295.7	+14.5	262		
			+44.5	298.7	+14.5		293	
			+54.5	308.7	+8.5	31		
			+55.5	309.7	+8.0		31	
			+65.5	319.7	+7.0	93		1,080
Sept. 16 (Naval Observatory).	11	33	−8.5	232.2	−11.0	154		
			+51.5	292.2	+14.0		401	
			+54.5	295.2	+14.5		216	
			+58.5	299.2	+14.0		370	
			+69.0	309.7	+8.0	31		
			+80.5	321.2	+6.5	77		1,249
Sept. 17 (Naval Observatory).	11	48	−83.5	143.8	+15.0	864		
			−74.0	153.3	−17.5		309	
			+5.5	232.8	−11.0	170		
			+63.5	290.8	+13.5		633	
			+71.5	298.8	+14.0		463	2,439
Sept. 18 (Mount Wilson)	13	20	−75.0	138.4	+15.0		1,274	
			−74.0	139.4	−22.0		216	
			−61.0	152.4	−19.0	243		
			+20.0	233.4	−11.0	232		
			+46.0	259.4	+17.0		17	
			+80.0	293.4	+15.0	1,372		3,354
Sept. 19 (Mount Wilson)	9	30	−78.5	123.8	+15.0	450		
			−68.0	134.3	+15.0		1,221	
			−65.0	137.3	−22.0		644	
			−49.0	153.3	−18.0	207		
			+31.0	233.3	−11.0	168		
			+60.0	262.3	+17.0		39	2,729
Sept. 20 (Naval Observatory).	11	29	−65.5	122.4	+15.0	278		
			−56.5	131.4	+14.0		93	
			−53.5	134.4	−21.0	355		
			−50.5	137.4	+15.0		478	
			−47.5	140.4	−18.0		293	
			−46.5	141.4	+15.0	355		
			−34.5	153.4	−17.5		185	
			+44.5	232.4	−11.0	108		
			+71.0	258.9	+17.5		93	2,238
Sept. 21 (Naval Observatory).	11	31	−75.5	99.2	−14.5	123		
			−52.0	122.7	+15.0	293		
			−40.0	134.7	−21.0	293		
			−38.5	136.2	+15.0		463	
			−32.5	142.2	+15.5	370		
			−32.5	142.2	−17.5		201	
			−20.5	154.2	−17.0	154		
			+58.5	233.2	−11.5	154		2,051
Sept. 22 (Naval Observatory).	11	20	−67.5	94.1	−16.5		293	
			−66.0	95.6	−10.0		31	
			−60.5	101.1	−14.0	170		
			−39.5	122.1	+15.5	201		
			−28.0	133.6	−21.0	201		
			−25.5	136.1	+15.0		417	
			−20.0	141.6	+15.5	401		
			−20.0	141.6	−17.0		247	
			−8.0	153.6	−16.5	123		
			+71.0	232.6	−11.5	123		2,207
Sept. 23 (Harvard)	15	17	−45.5	101.0	−15.0		1,256	
			−20.0	126.5	+15.5		281	
			−5.5	141.0	−18.5		59	
			−5.0	141.5	+15.5		1,043	
			+10.5	157.0	−16.5		224	2,863
Sept. 24 (Naval Observatory).	11	52	−36.0	98.9	−15.0		957	
			−11.5	123.4	+15.0		216	
			−1.0	133.9	−21.0		231	
			+1.5	136.4	+15.5		401	
			+6.0	140.9	−17.5		170	
			+6.5	141.4	+15.5	340		
			+18.5	153.4	−17.0		93	2,408
Sept. 25 (Mount Wilson)	11	30	−22.0	100.5	−17.0		1,552	
			−2.0	124.5	+15.0		223	
			+16.0	138.5	+16.0		774	
			+20.0	142.5	−18.0		100	
			+34.0	156.5	−16.0	131		2,870
Sept. 26 (Naval Observatory).	12	10	−73.0	35.4	+18.0		77	
			−9.5	98.9	−15.0		1,481	
			+14.5	122.9	+15.5		139	
			+27.5	135.9	+15.5		309	
			+29.0	137.4	−20.0		154	
			+32.0	140.4	+15.5	324		
			+45.5	153.9	−17.0	123		2,607
Sept. 27 (Naval Observatory).	12	24	−58.5	36.5	+17.5		62	
			+4.5	99.5	−15.0		1,481	
			+26.5	121.5	+15.5		62	
			+37.0	132.0	−21.5	93		
			+40.5	135.5	+15.5		201	
			+46.0	141.0	+15.5	355		
			+46.0	141.0	−18.0		93	
			+59.5	154.5	−17.0	123		2,470
Sept. 28 (Naval Observatory).	11	37	−48.0	34.3	+18.0		77	
			−26.5	55.8	−14.0		46	
			+13.0	95.3	−17.5		772	
			+21.0	103.3	−13.5		648	
			+39.5	121.8	+16.0	31		
			+53.0	135.3	+15.0		201	
			+55.0	137.3	−21.0		108	
			+58.5	140.8	+15.5	370		
			+71.5	153.8	−17.0	123		2,376
Sept. 29 (Harvard)	11	54	−33.0	36.0	+21.0		105	
			+33.5	102.5	−16.5		1,675	
			+76.0	145.0	+15.0		1,082	2,862
Sept. 30 (Mount Wilson)	12	00	−24.0	31.7	+19.0		37	
			−13.0	42.7	−17.0		32	
			+4.0	59.7	−14.0		12	
			+18.0	73.7	−7.0	8		
			+43.0	98.7	−17.0		1,063	
			+80.0	135.7	−21.0		32	
			+82.0	137.7	+15.0		257	1,441
Mean daily area for September								1,662

PROVISIONAL SUNSPOT RELATIVE NUMBERS FOR SEPTEMBER, 1928

[Data furnished by Prof. A. Wolfer, University of Zurich, Switzerland]

September	Relative numbers	September	Relative numbers	September	Relative numbers
1	63	11		21	98
2	47	12	89	22	109
3	76	13		23	115
4	73	14	54	24	130
5	57	15	56	25	144
6	47	16		26	136
7	55	17	46?	27	152
8	96	18		28	111
9	89	19	85	29	107
10	85	20	103	30	111

Number of observations, 26; mean, 89.8.

AEROLOGICAL OBSERVATIONS

By L. T. SAMUELS

Free-air temperatures for September averaged below normal at all stations and levels. (See Table 1.) In most cases the departures were of considerable magnitude. Free-air relative humidities, likewise, averaged below normal, and it is interesting to note that at Royal Center, where the departures were appreciable for both of these elements, the monthly precipitation amounted to only 0.57 inch, or 2.91 inches less than normal. Vapor pressures, in agreement with the average temperatures, were consistently below normal at all stations and levels.

The relationship between the negative temperature departures and the deviation of the resultant winds from their normal is particularly striking. (See Table 2.) It will be seen that the south component at Broken Arrow is consistently less than normal. At Ellendale the deviation from normal is especially pronounced, the resultant for the month containing a marked north component as compared with a normal south component. Moreover, the resultant velocities at this station were decidedly above normal. At Groesbeck a north component predominated instead of the normal south component, while at Royal Center there was a deficiency in the amount of the south component.

The largest deviation is found at Due West but, owing to the relatively few kite observations possible at that station during the month, a comparison was made between the resultant winds as indicated by the morning pilot-balloon observations and the normals as shown in Table 2. This revealed a preponderance of northwesterly winds as compared to a normal component from the northeast.

On the morning of the 18th, when the tropical hurricane began to recurve toward the northeast, pilot-balloon observations made at stations along its western periphery revealed strong northerly and northeasterly winds to at least 3,000 meters. A kite flight of unusual interest was made at Royal Center on the morning of the 19th, when this storm was centered over the North Carolina coast and showed an abnormally low lapse rate, 0.08° C. per 100 meters, between the surface and 3,800 meters. However, from 3,800 to 4,500 meters the lapse rate was much higher, being 0.85° C. per 100 meters. The relative humidity decreased to less than 20 per cent above 1,700 meters and to less than 5 per cent at 4,500 meters. The wind remained northeasterly throughout the 4,500-meter air column and cirrus clouds were moving from the east.

In this connection it is interesting to note that during the following 24 hours the storm changed its direction of movement from northeastward to north-northwestward and decreased considerably in intensity.

The great heights to which these tropical storms extend as compared with the extratropical storms is further indicated by the pilot-balloon observation of New Orleans on the 18th, at which time the storm center was over Savannah, Ga. This observation showed a wind from the north to at least 7,000 meters.

TABLE 1.—*Free-air temperatures, relative humidities and vapor pressures during September, 1928*

Altitude m. s. l.	Broken Arrow, Okla. (233 meters)		Due West, S. C. (217 meters)		Ellendale, N. Dak. (444 meters)		Groesbeck, Tex. (141 meters)		Royal Center, Ind. (225 meters)		*Washington, D. C. (7 meters)	
	Mean	Departure from normal	Mean	Departure from normal	Mean	Departure from normal	Mean	Departure from normal	Mean	Departure from normal	Mean	Departure from normal
	TEMPERATURE (°C.)											
Meters												
Surface	19.9	−3.3	18.4	−5.0	12.3	−2.1	20.1	−4.0	15.2	−5.0	19.6	−1.8
250	19.8	−3.3	18.1	−4.9			20.4	−3.1	15.1	−4.9	18.2	−1.9
500	19.0	−2.7	16.5	−4.3	12.5	−1.9	20.2	−1.9	14.4	−3.8	17.0	−1.9
750	18.2	−2.3	15.5	−3.8	12.1	−1.7	19.3	−1.5	12.9	−3.8	15.7	−2.1
1,000	17.5	−1.8	14.9	−3.3	11.1	−1.8	18.7	−0.9	11.2	−4.0	14.4	−2.4
1,250	16.9	−1.2	13.7	−3.2	10.2	−1.8	17.8	−0.6	9.7	−4.0	13.2	−2.6
1,500	16.0	−0.9	12.2	−3.4	9.1	−1.8	16.6	−0.7	8.3	−4.0	12.2	−2.5
2,000	13.6	−0.7	9.2	−3.8	6.1	−2.3	13.7	−1.2	5.9	−3.8	10.2	−2.4
2,500	10.8	−0.7	6.7	−3.5	2.7	−2.8	11.4	−1.1	3.5	−3.5	7.9	−2.6
3,000	8.2	−0.4	4.5	−3.0	−0.1	−2.6	8.4	−1.6	1.2	−3.4	5.3	−2.6
3,500	5.4	−0.2	1.1	−3.9	−1.6	−1.4	4.6	−2.8	−1.7	−3.6	2.3	−2.7
4,000	1.7	−0.8	0.7	−1.9	−5.0	−2.0	1.7	−2.9	−4.0	−3.5		
4,500					−8.6	−2.8			−8.0	−4.2		
5,000									−11.3	−4.2		
	RELATIVE HUMIDITY (%)											
Surface	64	−4	76	+9	66	−2	73	−3	68	0	68	−8
250	64	−4	76	+9			70	−6	67	−1	64	−11
500	57	−9	73	+4	63	−3	65	−11	58	−9	50	−14
750	54	−10	69	0	55	−7	59	−16	57	−10	56	−15
1,000	53	−10	66	−3	51	−9	53	−18	57	−9	55	−15
1,250	50	−12	64	−5	49	−8	48	−19	56	−9	54	−14
1,500	48	−12	66	−4	45	−9	51	−13	55	−9	52	−15
2,000	45	−10	64	−2	43	−8	49	−10	45	−14	47	−15
2,500	43	−8	61	−3	46	−5	36	−17	40	−16	42	−12
3,000	40	−8	51	−9	39	−11	34	−15	38	−14	42	−9
3,500	34	−15	52	−3	27	−20	36	−10	39	−11	45	0
4,000	40	−7	48	−9	31	−14	34	−8	33	−13		
4,500					41	−2			33	−9		
5,000									34	−9		
	VAPOR PRESSURE (mb.)											
Surface	15.27	−4.14	16.53	−2.66	9.42	1.93	17.59	−5.21	12.41	−3.91	16.42	−3.29
250	15.11	−4.17	16.08	−2.81			17.03	−5.04	12.25	−3.87	14.13	−3.76
500	13.16	−4.19	14.15	−2.93	9.04	2.06	15.62	−4.68	10.54	−3.88	11.91	−4.28
750	11.75	−3.90	12.76	−2.84	7.75	2.27	13.50	−4.87	9.48	−3.75	10.26	−4.36
1,000	10.98	−3.37	11.67	−2.86	6.83	2.25	11.50	−4.70	8.40	−3.52	9.23	−4.30
1,250	9.82	−3.25	10.35	−3.13	6.10	2.03	9.74	−4.56	7.55	−3.32	8.37	−3.95
1,500	8.95	−2.69	9.69	−2.93	5.22	2.05	9.44	−3.23	6.73	−3.00	7.56	−3.73
2,000	6.98	−1.92	7.38	−2.96	4.25	1.68	7.45	−2.41	4.81	−2.77	6.00	−3.10
2,500	5.33	−1.34	5.84	−2.73	3.46	1.44	4.58	−2.95	3.69	−2.19	4.46	−2.36
3,000	4.01	−1.00	4.41	−2.81	2.56	1.55	3.72	−2.16	2.89	−1.56	3.60	−2.10
3,500	2.58	−1.42	3.98	−2.25	1.69	1.60	3.34	−1.35	2.34	−1.02	2.83	−1.50
4,000	1.92	−1.05	3.62	−2.17	1.56	1.11	2.77	−0.82	1.38	−0.90		
4,500					1.36	0.74			1.27	−0.84		
5,000									1.23	−0.84		

* Naval air station.

TABLE 2.—*Free-air resultant winds (m. p. s.) during September, 1928*

Altitude m. s. l.	Broken Arrow, Okla. (233 meters)				Due West, S. C. (217 meters)				Ellendale, N. Dak. (444 meters)			
	Mean		Normal		Mean		Normal		Mean		Normal	
	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity
Meters	°		°		°		°		°		°	
Surface	S. 22 E.	1.6	S. 2 E.	3.2	N. 68 E.	1.0	N. 59 E.	2.6	N. 64 W.	2.6	N. 71 W.	0.6
250	S. 27 E.	1.9	S. 2 E.	3.3	N. 65 E.	0.9	N. 58 E.	2.5	----	----	----	----
500	S. 14 E.	2.5	S. 7 W.	4.5	N. 54 E.	0.5	N. 53 E.	2.7	N. 68 W.	2.7	S. 81 W.	0.7
750	S. 9 W.	2.5	S. 14 W.	5.3	S. 16 W.	0.4	N. 61 E.	3.1	N. 72 W.	3.0	S. 61 W.	1.3
1,000	S. 34 W.	2.7	S. 24 W.	5.2	S. 30 W.	1.8	N. 67 E.	2.8	N. 69 W.	3.4	S. 63 W.	1.8
1,250	S. 67 W.	2.5	S. 30 W.	5.0	S. 58 W.	2.7	N. 53 E.	2.7	N. 73 W.	4.1	S. 64 W.	2.6
1,500	S. 72 W.	3.0	S. 39 W.	5.0	S. 76 W.	4.2	N. 53 E.	2.0	N. 71 W.	4.6	S. 71 W.	3.4
2,000	S. 86 W.	4.0	S. 46 W.	5.7	S. 29 W.	2.0	N. 63 E.	1.8	N. 67 W.	6.0	S. 77 W.	4.8
2,500	S. 86 W.	4.2	S. 53 W.	5.4	S. 77 W.	7.5	N. 42 E.	0.9	N. 70 W.	7.2	S. 81 W.	6.7
3,000	W.	5.3	S. 51 W.	6.2	N. 83 W.	9.6	N. 41 W.	0.9	N. 67 W.	9.0	S. 87 W.	8.9
3,500	S. 68 W.	6.3	S. 53 W.	6.3	N. 77 W.	10.4	N. 1 E.	2.1	N. 57 W.	14.0	W.	10.7
4,000	S. 75 W.	7.2	S. 69 W.	7.5	N. 67 W.	12.0	N. 29 W.	3.9	N. 44 W.	15.8	N. 81 W.	12.0
4,500	S. 80 W.	6.6	S. 87 W.	8.8	N. 67 W.	14.0	N. 38 W.	8.4	N. 45 W.	14.0	N. 80 W.	13.1
5,000	----	----	----	----	----	----	----	----	N. 45 W.	14.0	N. 85 W.	14.5

Altitude m. s. l.	Groesbeck, Tex. (141 meters)				Royal Center, Ind. (225 meters)				Washington, D. C. (34 meters)			
	Mean		Normal		Mean		Normal		Mean		Normal	
	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity	Direction	Velocity
Meters	°		°		°		°		°		°	
Surface	N. 68 E.	1.6	S. 24 E.	1.7	S. 66 W.	1.8	S. 45 W.	1.4	N. 60 W.	0.7	N. 7 W.	0.7
250	N. 78 E.	2.8	S. 24 E.	2.4	S. 70 W.	2.0	S. 45 W.	1.6	N. 58 W.	2.3	N. 25 W.	1.1
500	E.	3.8	S. 15 E.	3.7	S. 81 W.	3.8	S. 50 W.	3.4	N. 50 W.	2.7	N. 36 W.	1.3
750	N. 81 E.	3.1	S. 7 E.	4.0	S. 82 W.	5.0	S. 58 W.	4.4	N. 50 W.	3.5	N. 40 W.	1.7
1,000	N. 65 E.	2.7	S. 4 E.	4.2	N. 88 W.	5.5	S. 66 W.	5.1	N. 51 W.	3.8	N. 44 W.	2.7
1,250	N. 60 E.	2.8	S. 3 E.	4.3	N. 89 W.	6.0	S. 69 W.	6.2	----	----	----	----
1,500	N. 47 E.	3.8	S. 3 E.	4.2	S. 87 W.	7.1	S. 73 W.	6.8	N. 57 W.	6.6	N. 54 W.	4.4
2,000	N. 48 E.	4.2	S. 3 E.	3.8	N. 86 W.	8.2	S. 75 W.	8.5	N. 72 W.	7.9	N. 68 W.	5.7
2,500	N. 37 E.	3.8	S. 5 E.	3.7	N. 87 W.	9.7	S. 75 W.	10.2	N. 82 W.	8.7	N. 72 W.	6.5
3,000	N. 20 E.	4.4	S. 3 E.	3.6	N. 88 W.	10.1	S. 74 W.	12.4	N. 79 W.	11.4	N. 71 W.	6.8
3,500	N. 34 E.	5.5	S. 4 E.	2.7	N. 84 W.	8.5	S. 79 W.	11.8	N. 70 W.	10.4	N. 68 W.	7.4
4,000	N. 38 E.	5.4	S. 4 E.	2.8	N. 88 W.	8.5	S. 86 W.	10.5	N. 83 W.	14.7	N. 72 W.	8.4
4,500	----	----	----	----	N. 53 W.	9.3	N. 82 W.	9.0	S. 89 W.	10.1	N. 69 W.	8.0
5,000	----	----	----	----	N. 45 W.	18.0	N. 45 W.	18.0	N. 70 W.	8.9	N. 71 W.	7.8

WEATHER IN THE UNITED STATES

THE WEATHER ELEMENTS

By P. C. DAY

GENERAL CONDITIONS

The outstanding feature of the weather history of September, 1928, was that pertaining to the severe tropical hurricane that entered southeastern Florida near Palm Beach during the early evening of September 16, the full details of which appear elsewhere in this issue. This storm was among the most severe in the history of the Southern States, rivaling that occurring in the vicinity of Miami, Fla., September, 1926, in property damage, and greatly exceeding it in the number of deaths, mostly by drowning. Aside from the above the month was notably cool over the eastern two-thirds of the country, and there was a widespread deficiency in precipitation.

PRESSURE AND WINDS

The early days of the month showed moderately high pressure over most western districts and from the Ohio Valley northeastward to New England, with local precipitation over most Southern States from Texas northeastward to the middle Atlantic coast, some heavy falls being reported in this area. By the morning of the 3d precipitation had overspread the upper Mississippi Valley and upper Lake region, extending during the 4th into New England and the adjacent Canadian Provinces. During this period fair weather prevailed in nearly all central and western districts and, save for local rains along the south and middle Atlantic coasts from about the 5th to 7th, fair weather continued until near the end of the first decade in all parts of the country.

By the morning of the 10th cyclonic conditions had developed over the middle Great Plains and moderate to heavy precipitation occurred over considerable areas during the following three or four days from Texas northeastward to the Great Lakes and northern New England and westward over the upper Mississippi Valley into the Dakotas and adjacent Canadian Provinces. Immediately following this rain area a cyclone of moderate intensity advanced from British Columbia southeastward, reaching the lower Missouri Valley by the morning of the 14th when rain was falling over an extensive area. This cyclone moved northeastward to the upper Lakes by the following morning and precipitation became rather general southward to the lower Ohio Valley and eastward to the lower Lakes and over much of the Province of Ontario.

Following this, anticyclonic conditions overspread most western and northern districts, continuing for several days. In the meantime, however, a strong tropical hurricane had developed over the eastern portion of the West Indies and passed directly across the island of Porto Rico during the afternoon and night of the 13th doing immense damage to property and causing large loss of life as elsewhere shown in this REVIEW.

The generally fair weather prevailing over most of the country during and preceding the last-mentioned storm was largely terminated about the beginning of the third decade when cyclonic conditions developed in the middle Plains and by the morning of the 21st low pressure was central over the upper Lakes and light rains had fallen from Colorado northeastward to the Lake Superior region. During the following 24 hours the cyclone moved northeastward and rain occurred from the Lake region to northern New England. At the same time low pressure had developed over the lower Rio Grande Valley and heavy rains had occureed in southern Texas, extending during the 23d and 24th into the southern portions of the Gulf and South Atlantic States, and continuing over the more eastern portions of that area during the following 24 hours.

The latter part of the month continued mostly fair in the central and western portions, but in the more eastern sections local showers occurred along the Gulf coast and in portions of the Ohio Valley and Eastern States

In the far West precipitation was mainly absent until the 12th to 15th when showers, mostly light, overspread local areas from central California and portions of Nevada northward.

The sea-level pressure for the month as a whole was above normal over the central valleys and Rocky Mountains where anticyclonic conditions existed during much of the month, and it was less than normal over most eastern districts and locally in the far West.

The general distribution of the average pressure and the variations from the means of the preceding month, and the prevailing directions of the winds are shown on the various charts, while the details of the severe wind and other storms are shown in the table at the end of this section.

TEMPERATURE

The opening decade of September was largely cool in central, southern, and eastern portions, also west of the Cascade Mountains and along most of the northern border, but was warm in the far Southwest and the middle Rocky Mountain region.

The week ending the 18th was a trifle cooler than normal in the north-central portion and parts of the far Northwest, but was mild over most of the country, particularly from the southern Plains northeastward to the Middle Atlantic States.

The final 12 days of the month were mainly warm from the Rocky Mountains westward, but substantially everywhere east of the Rockies were cool for the season, particularly from the central valleys eastward and northeastward to the Middle Atlantic States and New England.

The month averaged warmer than normal in most of the far West, but practically normal on the immediate Pacific coast and likewise in Florida. In Montana and the Plains States and almost everywhere to eastward the month averaged cool, notably from the middle and upper Mississippi Valley eastward to near the Atlantic coast, where the deficiency was mainly 4° or more per day.

No unusually high marks for the season were reported save in portions of California, notably at Eureka, where on the 21st the maximum was the highest of record for September, and at Fresno, where the maximum the same day was the highest so late in autumn. Locally in the far West and generally in the Plains region the highest temperatures were reached during the opening week, but near and to eastward of the Mississippi River they occurred chiefly during the period from the 10th to 15th.

The lowest readings occurred almost always from the 24th to the 28th in the Plains States and to eastward, about the 14th in the far Southwest, about the 9th in the western and northern Plateau districts, and elsewhere on scattered dates.

Killing frosts occurred in many north-central and some central districts during the last week, those at Louisville, Ky., on the 26th and at Peoria, Ill., on the 27th being the earliest known in a period of over 50 years. In general, staple crops were better matured than usual in late September, so the damage was not great.

PRECIPITATION

Over by far the larger part of the country the total rainfall of September was decidedly less than normal; but in the States where the fall was more than normal the excess was often very great. Owing chiefly to notable rains during the first week and to the effects of the hurricane moving northward from the Tropics, just after the middle of the month, most Atlantic Coast States received very heavy rains. The monthly amounts were from two to five times the normal over the eastern halves of the Carolinas and local points had the greatest September precipitation of record. Considerable areas visited by these heavy downpours had already experienced excessive rains in connection with the two severe storms of August, though the region of heaviest rains in September was situated chiefly to eastward of the region where the August downpours were greatest.

The State average of North Carolina was greater than ever before in September, and the South Carolina average very closely approached the previous record. Among individual stations, Marion, S. C., reported the greatest monthly total, 27.06 inches.

In most counties of New York and Pennsylvania the September rainfall was somewhat scanty, likewise in northern New Jersey and parts of New England.

Outside of the Atlantic States heavy precipitation occurred in extreme southeastern Louisiana and over most of southern Texas. The amount for Corpus Christi was 15.89 inches, making this the wettest September in over 40 years of record. The northern part of the upper Lake region and some portions of the upper Mississippi Valley had more than the normal September precipitation.

In the Ohio Valley and the southern portion of the Lake region, also in most of the Missouri Valley, September was much drier than normal, and particularly was the month dry from central Tennessee and northwestern Alabama westward to northern Texas, Oklahoma, and southern Kansas. In Oklahoma and Arkansas this was the driest September of those for which averages have been computed and a number of points in the Ohio Valley and near-by areas also had the least precipitation of record for September.

Central, eastern, and southern Nevada and the southern half of California were practically without rain, while nearly all other parts of the Pacific, Plateau, and Rocky Mountain regions had much less than the normal quantities.

SNOWFALL

Over a number of scattered districts in the northern third of the country and in a few mountain areas farther south snow occurred, but mainly in trifling amounts.

In southeastern Idaho and southwestern Montana a few inches fell locally, Conway's ranch, in the latter State, reporting the greatest amount, 4.5 inches, on the 12th and 13th.

In northern Michigan, especially the western half of the upper peninsula, rather unusual snowfall for such an early date occurred on the 23d to 25th, Houghton reporting 3.8 inches, while at a number of stations in that area it was the earliest occurrence of snow in 50 years or more.

A few stations in the mountains of western Maryland reported a snow flurry on the 25th, the earliest occurrence of record for that district.

RELATIVE HUMIDITY

Over the States of the Atlantic coast the average percentages of relative humidity were very generally greater than normal, also over southern Texas, and in portions of the Lake region, thus outlining with considerable accuracy the regions with more than normal precipitation. At a few points in the far West there were also small areas where the humidity percentages were above the normal despite the general absence of appreciable precipitation. Elsewhere humidity precentages were practically everywhere materially less than normal, as would be expected due to the general absence of material precipitation. As a result of low humidity the fire hazard was greatly increased in the western forest areas, though fortunately no severe fires occurred.

CLOUDINESS AND SUNSHINE

The month was notably free over large areas from extensive periods of cloudiness, and sunshine prevailed to an unusual extent over most central and western districts. Along the Atlantic coast clouds prevailed to a considerable extent and the sunshine percentages were nearly everywhere less than normal.

SEVERE LOCAL STORMS, SEPTEMBER, 1928

[The table herewith contains such data as have been received concerning severe local storms that occurred during the month. A more complete statement will appear in the Annual Report of the Chief of Bureau.]

Place	Date	Time	Width of path, yards	Loss of life	Value of property destroyed	Character of storm	Remarks	Authority
Floyd County, Tex. (western).	3					Hail and electrical.	Severe damage to crops over path 5 miles long.	Official, U. S. Weather Bureau.
Meade and Clark Counties, Kans.	4	5-5:30 p.m.	7 miles		$100,000	Severe hail	Damage chiefly to growing crops, roofs, and windows; poultry killed; path, 25 miles.	Do.
Harper County, Okla	4	5:30 p. m.	5 miles		30,000	Heavy hail	Damage chiefly to crops	Do.
Montgomery, Page, and Wayne Counties, Iowa.	10	P. m.				Rain and wind	Considerable crop damage; roads and bridges washed.	Do.
Sterling, Kans., and vicinity.	11	8:30 p. m.	1,760		5,000	Severe hail	Greenhouses, automobiles, and roofs damaged over path 2 miles long.	Do.
Van Buren County, Iowa	11	9 p. m.				Wind and rain	Crops injured	Do.
Maryville, Mo	11	P. m.			500	Severe wind	Telephone poles and shade trees damaged	Do.
Fordyce, Nebr., to Davis, S. Dak.	13	3:15-4:40 p. m.	100	4	165,000	Tornado	Farm buildings wrecked; livestock killed	Do.
Pendar (near) to Dakota City, Nebr.	13	3:45 p. m.		4	750,800	do	Livestock killed, many buildings demolished or badly damaged; 40 persons injured; path 33 miles.	Do.
Marshall County, Kans	13	4-5 p. m.				Wind	Buildings damaged; trees uprooted, haystacks blown over.	Do.
Clay County, Kans. (northeastern).	13	P. m.				do	Barns, small buildings, telephone lines and crops damaged.	Do.
Denver, Colo., and vicinity	13				15,000	do	Injury chiefly to trees and parks; minor damage to buildings.	Do.
Lancaster, Pa., and vicinity.	13	P. m.			20,000	Electrical and wind.	Several buildings damaged; one building collapsed.	Do.
Rindge, N. H	13	do	300		50,000	Probably tornado.	Several homes wrecked; barns demolished; telephone lines and trees blown down; path 4 miles.	Boston Herald.
Calhoun, Pocahontas, Sioux, and Woodbury Counties, Iowa.	13	5-6 p. m.			67,000	4 tornadoes	Many dwellings and farm buildings wrecked; crops destroyed; 1 person injured.	Official, U. S. Weather Bureau.
Bremer County, Iowa	14	4 a. m.	440		20,000	Tornado	Character of damage not reported. Path 1 mile.	Do.
Fayette County, Iowa	14	do	400		40,000	do	Character of damage not reported. Path 16 miles long.	Do.
Rockford, Ill., and vicinity.	14	3:22 p. m.	200-500	14	1,200,000	do	About 30 city blocks affected; many farm buildings damaged; path 26 miles long; 100 persons injured.	Do.
Scottville, Mich. (near)	14	6:30 p. m.	116		20,000	do	Several barns completely wrecked; trees twisted; path 6 miles long.	Do.
Grand Rapids, Mich (southeast part of).	14	7:15 p. m.		8	110,000	Wind and electrical.	A number of buildings wrecked; 1 building badly damaged by lightning; path about 3 miles.	Do.
Rock, Green, Dane, and Waupaca Counties, Wis.	14				181,500	Severe wind and probably 3 small tornadoes.	Heavy property damage of various kinds; 13 persons injured.	Do.
South and Middle Atlantic coast.	16-20			1,836	27,760,000	Tropical hurricane.	Heavy damage to buildings, crops, water-front property, and public utilities; greatest losses in Florida.	Do.

RIVERS AND FLOODS

By R. E. SPENCER

Aside from the important floods in the Carolina rivers the only rise of consequence during September occurred in the lower Wisconsin River. This flood, the result of a period of fairly steady rainfall from the 10th to the 15th, was of moderate character, was accurately forecast so that levees and embankments could be guarded and strengthened where necessary, and its resultant losses are reported not to have exceeded $43,000, of which $28,850 was in matured crops. The value of property saved directly by the flood warnings was $1,000.

The rises in the Connecticut, the Altamaha, the French Broad, Big Pigeon, Hiwassee, the Grand of Missouri, the Canadian, and Rio Grande were all without damage, while along the James of Virginia only $150 loss occurred and $12,000 worth of property was saved through Weather Bureau flood warnings.

The first of the two floods in the Carolina rivers resulted from a period of rainfall in those States lasting generally from the 1st to the 5th, and the second from rains incident to the northward approach and passage of the tropical cyclone on the 17th, 18th, and 19th. In general, the floods of the later period were the more severe, not only because of heavier rains but also in large measure because overflow from the preceding rises had not yet drained from lowlands and swamps along the lower reaches of the streams at the time of approach of the second flood. August stages were exceeded in all streams except the Roanoke of Virginia and North Carolina and the Santee system of South Carolina; and in the lower reaches of at least four of the gaged rivers high water records were broken. These are the Cape Fear, where the stage of 41.3 feet at Elizabethtown, N. C., exceeded the previous record of August 29, 1908, by 0.3 foot; the Waccamaw, where the stage of 13.4 feet at Conway, S. C., exceeded the previous record of October 9-10, 1924, by 2.3 feet; the Peedee, where the stage of 29.6 feet at Mars Bluff, S. C., exceeded the previous record by 0.6 foot; and the Black, where the stage of 18 feet at Kingstree, S. C., exceeded the previous record of July 17, 1916, by 2.5 feet.

Flood warnings, issued well in advance of the damaging stages, and distributed by every available means, effected a saving reported to have amounted to $570,250, mainly, as usual, in the removal of household goods and livestock and in the gathering of matured or nearly matured crops. In addition, as reported by the official in charge of the Weather Bureau office at Raleigh, N. C.—

A number of railroad and other bridges were weighted down as a precaution with coal cars, and lumber, brick, cotton, and other manufacturing plants were protected as far as possible. Warnings were of much interest in protecting levees on the Roanoke in danger from repeated overflows, and to the State highway commission in giving advance notice of closing and opening of highways and in connection with bridges and approaches thereto.

But despite the generally effective distribution of warnings and the advantage taken of them, losses were nevertheless very heavy. The following statement, quoted

from the report of the official in charge of the Weather Bureau office at Columbia, S. C., is suggestive of conditions in other districts as well as his own:

It is generally accepted that the September floods were more damaging than the August floods, especially as to highways and crops, the latter being practically ruined in extensive areas, while the highway commission has made increased allotments over the August sums for road repairs. On account of much lighter rainfall in the Piedmont sections, the principal damage occurred in the central basins and the lower reaches.

This report also states that on account of damaged culverts two railroad trains were wrecked in South Carolina and five persons killed, the damage to the culverts having been due to undermining and seepage from the rains and floods. These were the only deaths reported. The total monetary loss, however, is reported to have reached a total of $4,004,050. Of this amount at least $2,000,000 was in crops, about evenly divided between the two States.

[All dates in September except as otherwise specified]

River and station	Flood stage	Above flood stages—dates: From—	Above flood stages—dates: To—	Crest: Stage	Crest: Date
ATLANTIC DRAINAGE	Feet			Feet	
Connecticut: Bellows Falls, Vt	12	18	19	12.2	19
		30	(1)	12.3	30
James:					
Columbia, Va	18	7	7	24.0	7
Richmond, Va	10	7	7	11.8	7
Roanoke:					
Randolph, Va	21	7	------	24.8	8
		20	------	26.1	21
Weldon, N. C	30	7	10	36.6	9
		20	25	42.0	23
Dan:					
Danville, Va	8	20	20	8.3	20
Clarksville, Va	12	21	22	13.0	22
Tar:					
Rocky Mount, N. C	9	5	8	9.9	7
		19	24	13.6	20
Tarboro, N. C	18	9	11	20.7	10
		20	28	29.0	24
Greenville, N. C	14	10	13	15.7	12
		20	(1)	21.9	24–25
Fishing Creek: Enfield, N. C	15	19	22	16.7	20
Neuse:					
Neuse, N. C	15	6	9	16.3	9
		19	25	20.0	22
Smithfield, N. C	14	4	11	21.5	7
		18	26	23.0	21
Cape Fear:					
Fayetteville, N. C	35	4	10	55.5	8
		19	25	64.7	22
Elizabethtown, N. C	22	4	13	35.7	9
		19	28	41.3	23
Haw: Moncure, N. C	22	6	7	27.0	6
		19	22	30.3	20
Waccamaw: Conway, S. C	7	14	(1)	13.4	30
Peedee:					
Cheraw, S. C	27	5	9	37.7	7
		19	23	42.0	20
Mars Bluff, S. C	17	5	(1)	29.6	23
Lynches: Effingham, S. C	14	5	14	19.0	11
		18	28	19.4	20 and 24
Black: Kingstree, S. C	12	6	14	15.6	8
		19	28	18.0	21
Santee:					
Rimini, S. C	12	(2)	(1)	30.4	Aug. 21
Ferguson, S. C	12	(2)	(1)	20.6	Aug. 22
Catawba: Catawba, S. C	12	6	7	14.0	7
		18	20	17.5	18
Wateree:					
Camden, S. C	24	5	8	33.2	6
		18	22	32.5	19
Malta, S. C	14	8	8	14.0	8
		21	22	14.5	22
Congaree: Columbia, S. C	15	6	7	26.2	6
		19	20	19.6	19
Broad: Blairs, S. C	15	6	7	18.5	6
		19	20	19.0	19
Saluda: Chappells, S. C	14	6	6	16.4	6
		19	19	14.4	19
ATLANTIC DRAINAGE—continued					
Altamaha:	Feet			Feet	
Charlotte, Ga	15	(2)	1	26.2	Aug. 22
		7	21	18.9	11
Everett City, Ga	10	(2)	30	15.0	Aug. 27–28
Oconee: Milledgeville, Ga	22	5	6	26.5	6
Ocmulgee:					
Macon, Ga	18	6	6	18.1	6
Abbeville, Ga	11	6	15	13.0	12
MISSISSIPPI DRAINAGE					
French Broad: Asheville, N. C	4	3	3	5.0	3
		6	8	5.0	6
Big Pigeon: Newport, Tenn	6	3	3	6.0	3
		6	6	6.5	6
Hiwassee: Charleston, Tenn	22	3	3	22.6	3
Wisconsin:					
Knowlton, Wis	12	15	17	16.9	16
Portage, Wis	17	19	21	18.1	20
Grand:					
Gallatin, Mo	20	12	16	28.2	15
Chillicothe, Mo	18	12	18	27.8	16
Brunswick, Mo	12	17	19	12.2	18
Canadian: Logan, N. Mex	4	------	------	5.0	2
WEST GULF DRAINAGE					
Rio Grande: San Benito, Tex	23	25	26	23.9	26

[1] Continued at end of month.

[2] Continued from last month.

MEAN LAKE LEVELS DURING SEPTEMBER

By UNITED STATES LAKE SURVEY

[Detroit, Mich., October 5, 1928]

The following data are reported in the Notice to Mariners of the above date:

Data	Lakes[1]: Superior	Michigan and Huron	Erie	Ontario
Mean level during September, 1928:	Feet	Feet	Feet	Feet
Above mean sea level at New York	603.40	580.44	572.12	246.17
Above or below—				
Mean stage of August, 1928	+0.38	−0.06	−0.47	−0.47
Mean stage of September, 1927	+0.74	+1.26	+0.48	+0.90
Average stage for September, last 10 years	+1.17	+0.57	+0.16	+0.63
Highest recorded September stage	−0.64	−2.90	−1.82	−1.44
Lowest recorded September stage	+2.07	+2.22	+1.19	+2.17
Average departure (since 1860) of the September level from the August level	+0.05	−0.20	−0.26	−0.41

[1] Lake St. Claire's level: In September, 1928, 575.16 feet.

EFFECT OF WEATHER ON CROPS AND FARMING OPERATIONS, SEPTEMBER, 1928

By J. B. KINCER

General summary.—A continuation of heavy rain during the first decade over an area from New Jersey and Pennsylvania southward was very detrimental to farming operations and crops, with much work delayed and crops damaged. Elsewhere it was mostly favorable for outdoor work, but fall plowing was hindered by hard, dry soil in many interior districts and a general rain was needed over most of the interior valley States.

During the second decade a tropical hurricane which struck the Florida peninsula on the 16th–17th, brought torrential rains and high winds to most sections from Florida northeastward to Pennsylvania. The weather

was favorable for farm work in many other sections, especially in the Northeast and the Ohio Valley, and in parts of the upper Mississippi Valley rains were of benefit, although they caused some delay to threshing, plowing, and seeding. There was very little rain from the Rocky Mountains westward, but in the Pacific Northwest beneficial showers checked forest fires and improved soil moisture.

Toward the close of the month, conditions improved materially in the Southeast, where the hurricane of the previous decade had wrought much damage through washing soil, flooding lowlands, and delaying farm work. There was a widespread need of rain for fall pastures, and in the principal wheat areas, also, moisture was needed. The frosts, which occurred unusually early in some sections, caused no material harm, as most staple crops had matured.

Small grains.—Late threshing made good advance during the first decade in the more northern and northwestern States under generally favorable weather and was well along or completed in most districts. Preparations for wheat seeding were delayed by hard, dry soil in much of the Wheat Belt. Flax was being threshed in the northern Great Plains and other small grains were doing well.

During the second decade rains interfered with threshing in central-northern districts, while in Minnesota spring wheat deteriorated, with damage from sprouting in shock. Harvest and threshing made good advance in the West and far Northwest. Fall plowing and seeding became rather general, but rain was needed in many sections; early seeded small grains did well.

Fall plowing and seeding made mostly slow progress during the last decade, due to the generally dry conditions; in the central and northern Great Plains much of the wheat crop had been sown and some was reported coming up to good stands. It was too dry in many portions of the Ohio Valley, but farther east seeding made good advance. Gathering of other small grains progressed well.

Corn.—Much corn was safe from frost in the first decade, with the crop ripening rapidly in the Ohio Valley and about normal maturing indicated in Iowa. Dry soil caused some deterioration in Nebraska, but in the southern Great Plains rapid ripening was reported, with the bulk of the crop safe in Kansas. Elsewhere corn progressed well, except for damage by continued wet weather in the Southeast. During the second decade rapid ripening was reported in the main Corn Belt with much cut for silage and fodder. Only local frost damage occurred and much of the crop was out of frost danger. In the Ohio Valley rapid advance toward maturity was made, and progress and condition were fair to very good in Iowa, while in Missouri normal ripening occurred. The crop was well advanced in the Great Plains and in most other portions it made good advance.

Cotton.—It was again too wet for cotton in the Atlantic Coast States during the first decade and, especially in Georgia, there were reports of bolls rotting, seed sprouting, and plants shedding to an unusual extent. In central sections progress of the crop was mostly fair to very good, while in Oklahoma advance was fair. In Texas progress continued mainly poor, with the rains too late to be of benefit; the general condition of the crop was spotted and considerable shedding was noted.

During the second decade there was some improvement in North Carolina, but the crop was at a standstill in parts of South Carolina. In Georgia cotton was opening rapidly, but many rotting bolls were evident and shedding continued. In central sections progress varied widely; advance was very good in Arkansas and the crop was largely made in Louisiana. In Oklahoma fairly good progress was reported and the crop was opening nicely, but in Texas condition varied, ranging from poor to very good, depending on the moisture supply; progress in this State averaged fair and picking and ginning made very good advance.

During the last decade high winds, heavy rains, and flooded lowlands did much damage to cotton in the eastern portions of the belt, but toward the close of the month better weather occurred and considerable recovery was reported. In the central States of the belt the weather favored opening and conditions were generally favorable for picking and ginning. In Oklahoma opening was favored and harvest advanced rapidly, while in Texas there was little change in the situation, although picking and ginning progressed well.

Miscellaneous crops.—Pastures needed rain in the Ohio Valley, but elsewhere in the East they were generally satisfactory; there was a rather widespread need of moisture in western parts. Except for some local blight, potatoes did well and truck made mostly satisfactory progress. Sugar cane was developing satisfactorily and sugar beets were ready to dig at the close of the month. Citrus did well, except for some storm damage in Florida, and deciduous fruits developed satisfactorily.

WEATHER OF THE ATLANTIC AND PACIFIC OCEANS

NORTH ATLANTIC OCEAN

By F. A. YOUNG

The outstanding feature of the weather during September was the tropical hurricane that prevailed during the second decade of the month. This storm may be classed as one of the most severe on record and is fully described elsewhere in the REVIEW. A map of the track is also shown and Charts VIII to XV, which cover the period from the 11th to the 19th, give an idea of the extent and intensity of the hurricane, as well as of the conditions which prevailed over the northern portion of the ocean.

The number of days with gales was considerably above the normal over the eastern section of the steamer lanes, as they were reported on 6 days in the squares between 45° to 50° N., and 20° to 30° W. West of the 40th meridian, gales of extra-tropical origin occurred on from 1 to 3 days.

TABLE 1.—*Averages, departures, and extremes of atmospheric pressure at sea level, 8 a. m. (seventy-fifth meridian). North Atlantic Ocean, September, 1928*

Stations	Average pressure	Departure [1]	Highest	Date	Lowest	Date
	Inches	*Inch*	*Inches*		*Inches*	
Julianehaab, Greenland	29.73	(2)	30.36	27th	29.16	1st.
Belle Isle, Newfoundland	29.88	−0.02	30.14	20th	29.64	29th.
Halifax, Nova Scotia	30.07	+0.06	30.50	20th	29.76	22d.
Nantucket	30.05	+0.01	30.36	6th	29.70	26th.
Hatteras	30.01	−0.02	30.20	5th [3]	29.30	19th.
Key West	29.93	−0.04	30.10	1st	29.58	17th.
New Orleans	29.98	−0.01	30.10	9th	29.82	18th.
Cape Gracias, Nicaragua	29.84	−0.04	29.94	1st	29.76	16th. [3]
Turks Island	30.02	+0.05	30.10	1st [3]	29.86	14th. [4]
Bermuda	30.14	+0.09	30.34	6th	29.84	23d.
Horta, Azores	30.10	−0.06	30.44	9th	29.58	25th.
Lerwick, Shetland Islands	29.97	+0.13	30.34	15th	29.72	6th.
Valencia, Ireland	30.08	+0.09	30.48	15th	29.54	28th.
London	30.12	+0.12	30.35	15th	29.61	28th.

[1] From normals shown on Hydrographic Office Pilot Chart, based on observations at Greenwich mean noon, 7 a. m., seventy-fifth meridian.
[2] No normal available.
[3] On other dates.
[4] Probably lower on 15th, which is missing.

The number of days with fog was apparently above normal along the New England coast, about normal over the middle sections of the steamer lanes, and somewhat below over the Grand Banks and off the European coast. From the 2d until the 5th a tropical disturbance of moderate intensity moved slowly westward over the Caribbean Sea. The American S. S. *San Benito* on the evening of the 4th ran into a severe squall off Cape San Antonio, accompanied by heavy rain and suddenly shiftings winds of a maximum force of 8, though the barometer readings varied but little during the night. The American S. S. *Norma*, in 20° 30′ N., 81° 07′ W., near midnight of the 3d, encountered a heavy ESE. to SE. squall of force 8 to 10, with a rough cross sea.

On the 5th a LOW was central about 10 degrees east of Belle Isle that afterwards developed into by far the most severe storm of the month in northern waters. On the 6th the steamer lanes between the fifteenth and forty-fifth meridians were swept by heavy gales, with a maximum force of 12, as shown by storm reports in table from the American S. S. *Tulsa*. By the 7th this disturbance had decreased considerably both in intensity and extent, although on that date moderate to strong gales were encountered between the twenty-fifth meridian and the Irish coast.

On the evening of the 9th a moderate depression was central near 27° N., 51° W., that moved slowly north accompanied by moderate winds until the morning of the 11th. By that date this LOW was near 40° N., 45° W., and had deepened considerably, with winds of force 7 near the center at the time of observation.

Chart VIII, for the 12th, shows the position of the tropical hurricane on that date and also that of the northern disturbance, just referred to, central near 43° N., 37° W. The latter LOW moved steadily northward and, as shown on Chart XII, was by the 16th near the coast of Iceland.

From the 17th to 19th conditions over the steamer lanes were comparatively quiet, but by the 20th a well-developed LOW of limited extent was central near 47° N., 40° W., accompanied by moderate northwesterly gales. On the 21st and 22d the center of this LOW was from 300 to 500 miles north of the Azores, and on both of these dates moderate gales were reported by vessels in the vicinity of these islands as well as in the eastern sections of the steamer lanes.

From the 22d to the 24th a depression was over the western portion of the Gulf of Mexico, although up to the time of writing no vessel reports have been received indicating a wind force higher than 6 in that region.

From the 24th to 30th moderate to strong gales were reported from the steamer lanes east of the thirtieth meridian, although the storm area varied considerably from day to day, reaching its greatest intensity on the 28th and 29th.

From the 25th to 29th there was also a comparatively slight disturbance in the vicinity of Newfoundland and Nova Scotia, with a maximum wind force of 9 at Belle Isle on the 26th.

Note.—American S. S. *Stanley*, Capt. C. H. Longbottom; observer, J. P. Hays. From Port Said to New York.

September 17, 12.50 p. m., ship's time. In 39° 25′ N., 63° 25′ W., a whirlpool about 500 feet in diameter passed vessel about 1 mile to the northward. Whirlpool was traveling to the eastward at about 20 knots and was churning up the water and sending up a column to a height of about 40 feet. Whirlpool seemed to be caused by an eddy of wind coming from a low dark nimbus cloud directly above it, with which it seemed to keep pace. It did not appear to be a waterspout in process of formation, as nothing but a fine spray was carried into the air. Barometer 30.12 inches. Dry-bulb, 91°, wet, 82°, water 80°.

OCEAN GALES AND STORMS, SEPTEMBER, 1928

Vessel	Voyage From—	Voyage To—	Position at time of lowest barometer Latitude	Position at time of lowest barometer Longitude	Gale began	Time of lowest barometer	Gale ended	Lowest barometer	Direction of wind when gale began	Direction and force of wind at time of lowest barometer	Direction of wind when gale ended	Highest force of wind and direction	Shifts of wind near time of lowest barometer
NORTH ATLANTIC OCEAN			° ′	° ′				Inches					
Dania, Dan. S. S.	Montreal	Copenhagen	59 32 N.	5 20 W.	Sept. 1	Noon, 2	Sept. 3	29.66	S	S., 8	W	S., 8	S.-SW.-W.
K. R. Kingsbury, Am. S. S.	Baltimore	Canal Zone	18 05 N.	75 17 W.	2	6 p., 2	3	29.85	SE	ESE., 7	E	SE., 8	Steady.
Marion, U. S. M. S.	Godthaab	Vineyard Haven.	58 55 N.	45 55 W.	3	3 p., 3	3	29.34		WNW., 7		WNW., 8	
Onondaga, Am. S. S.	Jacksonville	Canal Zone	19 42 N.	83 26 W.	4	Noon, 4	5	29.86	NNE	SE., 9	SE	SE., 9	NNE.-SE.
Hellig Olav, Dan. S. S.	New York	Christiansand.	51 19 N.	42 41 W.	4	10 p., 5	7	29.27	S	NW., 6	W	NW., 8	W.-NW.
Stockholm, Swed. S. S.	Gothenburg	New York	57 09 N.	36 00 W.	6	7 a., 6	6	28.81	Var	S., 7	WNW	NW., 10	SSE.-SSW.
Tulsa, Am. S. S.	Antwerp	Jacksonville	49 54 N.	20 00 W.	6	1 a., 6	7	29.47	SW	SW., 7	W	SSW., 12	
Grootendijk, Du. S. S.	London	Canal Zone	27 51 N.	51 36 W.	9	4 p., 9	10	29.98	SSE	ESE., 7	SSE	SE., 8	SSE.-E.
Westmoreland, Am. S. S.	Rotterdam	Galveston	34 04 N.	50 41 W.	10	4 p., 10	10	29.94	S	SSW., 8	W	—, 8	SSW.-W.
Conte Grande, Ital. S. S.	New York	Gibraltar	40 18 N.	43 22 W.	11	2 p., 11	12	29.08	NNE	ESE., 3	WSW	NNE., 9	NNE.-SE.
Irma Schindler, Ger. S. S.	Curacao	Havre	41 50 N.	36 04 W.	11	6 a., 12	13	29.33	SW	W., 11	NNW	W., 11	SW.-W.
Puerto Rico, Fr. S. S.	St. Nazaire	Canal Zone	14 40 N.	61 10 W.	12	3 p., 12	13	29.49	NW	W., 10	SE	W., 10	WNW.-WSW.
Ponce, Am. S. S.	New York	San Juan	20 28 N.	66 35 W.	13	4 p., 13	14	29.78	E	ENE., 9	SSE	E., 12	E.-ESE.
Henry Holmes, Br. S. S.	In port of St. Thomas		St. Thomas, V. I.		12	1 p., 13	14	29.23	NE	ENE., 12	SE	ENE., 12	NE.-ENE.
West Madaket, Am. S. S.	Manchester	Mobile	26 40 N.	70 46 W.	14	2 p., 14	16	29.90	E	ENE., —	SE	SSE., 10	
Wm. G. Warden, Am. S. S.	Baltimore	Danish West Indies.	20 45 N.	66 53 W.	13	—, 14	14	29.75	E	E., 9	SSE	E., 10	Steady.
Lord Kelvin, Br. S. S.	On cable repairs.		48 40 N.	34 31 W.	14	5 p., 14	15	29.71	SSW	SSW., 9	WNW	SSW., 9	W.-NW.-W.
Mary, Am. S. S.	New York	Dominican Republic.	19 53 N.	71 40 W.	14	1 a., 15	15	29.43	N	W., 9	S	NW., 9	NW.-W.
El Norte, Am. S. S.	do	Galveston	30 30 N.	80 30 W.	16	11 p., 16	19	28.92	ENE	ENE., —	W	SW., 12	SSW.-SW.
W. H. Tilford, Am. S. S.	Wilmington, N. C.	Baytown	24 45 N.	80 02 W.	16	Noon, 16	17	29.16	NE	NNW., 11	SW	NNW., 11	NNW.-NW.
Princeton, Am. S. S.	Baytown	Charleston	30 15 N.	79 24 W.	17	5 p., 18	19	29.47	SSW	W., 11	W	—, 12	Steady.
Nidarholm, Nor. S. S.	Baltimore	Habana	Jacksonville		16	2 a., 18	19	28.93	NE	N., —	W	NE., 11	NE.-N.-W.
Charles Pratt, Am. S. S.	New York	Texas City	32 20 N.	15 10 W.	17	4 a., 19	20	29.57	SE	S., 11	SW	S., 11	SSE.-S.
Harvester, Am. S. S.	Charleston	Port Arthur	31 46 N.	79 50 W.	17	6 a., 18	19	28.96	NE	SSW., 12	WNW	SSW., 12	S.-SSW.
Tulsa, Am. S. S.	Antwerp	Jacksonville	31 30 N.	72 00 W.	18	5 p., 18	19		SE	SE., 10	SW	SE., 10	
Brazos, Am. S. S.	New York	Galveston	38 22 N.	74 20 W.	19	10 p., 19	20	29.79	NE	E., 8	S	NE., 10	NE.-E.-S.
Minnekahda, Am. S. S.	Boulogne	New York	46 46 N.	39 23 W.	20	7 a., 20	21	29.61	SSW	SSW., 7	N	NNW., 9	SSW.-NW.
Edam, Du. S. S.	Vigo, Spain	New Orleans	29 45 N.	68 00 W.	22	Mdt., 22	23	29.79	S	SW., 6	NNW	SW., 8	SW.-W.
Mercer, Am. S. S.	New York	Rotterdam	49 04 N.	25 28 W.	23	4 p., 24	27	29.72		ENE., 5	E	ENE., 9	Steady.
Steel Worker, Am. S. S.	Port Said	Boston	38 35 N.	60 00 W.	24	5 a., 25	25	29.58	W	SW., 8	WNW	SW., 8	S.-W.-NW.
Yselhaven, Du. S. S.	Nordenham	Charleston	44 29 N.	60 20 W.	26	8 p., 26	28	29.74	ESE	ESE., 8	W	WSW., 10	SW.-SSE.-W.
Berlin, Ger. S. S.	New York	Bremen	49 28 N.	17 17 W.	27	—, 29	29	29.25	N	NNE., 12	ENE	NNE., 12	Steady.
NORTH PACIFIC OCEAN													
Protesilaus, Br. S. S.	Victoria	Yokohama	50 45 N.	177 55 W.	4	10 a., 5	5	29.46	S	S., 8	W	S., 8	S.-SSW.-W.
Invincible, Am. S. S.	Cebu	Honolulu	23 07 N.	142 50 E.	7	5 p., 8	9	29.37	E	W., —	S	NW., 9	
Steel Scientist, Am. S. S.	Honolulu	Manila	24 12 N.	147 00 E.	8	5 p., 8	9	29.51	SE	SE., 8	S	SE., 9	Steady.
Africa Maru, Jap. S. S.	Victoria	Yokohama	52 25 N.	162 31 W.	9	Noon, 11	12	29.36	WNW	W., 9	NW	WNW., 9	W.-WNW
Independence, Am. S. S.	San Pedro	Kobe	39 02 N.	165 04 E.	10	3 p., 10	10	29.53	ENE	NE., 8	N	NE., 8	Slight.
Chief Capilano, Br. S. S.	Osaka	Grays Harbor	50 25 N.	156 43 W.	10	Midt., 11	13	29.28	SW	W., 9	W	W., 9	Steady.
Everett, Am. S. S.	Hong Kong	San Francisco	27 35 N.	125 57 E.	13	8 a., 13	14	28.58	N	SW., 6	S	SSE., 12	N.-SW.-SSE.
Yankee Arrow, Am. S. S.	Shanghai	San Pedro	48 40 N.	174 30 W.	17	4 p., 17	17	29.84	S	SW., 6	WSW	S., 8	Steady.
Silverlarch, Br. M. S.	Surabaya	San Francisco	35 15 N.	168 55 W.	16	9 p., 17	18	29.83	NE	NE., —	SSE	NNE., 9	
Lancaster, Am. S. S.	Everett	Balboa	41 55 N.	124 40 W.	18	6 p., 18	18	29.92	N	N., 9	N	N., 9	Steady.
Egypt Maru, Jap. S. S.	Miike	Vancouver	43 21 N.	154 47 E.	23	4 p., 24	26	29.80		SE., 8		S., 9	
Tecumseh, Br. S. S.	San Pedro	Japan	32 15 N.	140 33 E.	25	2 p., 26	26	29.81	S	SSW., 7	WSW	S., 8	WSW.-SSW.

REPORTS OF STORMS OFF MEXICAN COAST

Vessel	Voyage From—	Voyage To—	Latitude	Longitude	Gale began	Time of lowest barometer	Gale ended	Lowest barometer	Direction of wind when gale began	Direction and force of wind at time of lowest barometer	Direction of wind when gale ended	Highest force of wind and direction	Shifts of wind near time of lowest barometer
Chattanooga City, Am. S. S.	Balboa	Honolulu	16 17 N.	115 50 W.	1	10 a., 2	2	29.55	NNE	WSW., 10	W	WSW., 10	WSW.-SW.
Santa Isabel, Am. S. S.	Canal Zone	do	17 52 N.	117 12 W.	1	9 a., 3	3	29.44	NE	WSW., 9	SW	WSW., 9	SSE.-SW.-W.
Onondaga, Am. S. S.	Jacksonville	San Pedro	13 22 N.	94 12 W.	13	1 p., 13	13	29.78	W	NW., 8	W	NW., 8	W.-NW.
Buffalo Bridge, Am. S. S.	San Pedro	New York	19 15 N.	105 30 W.	17	10 p., 17	18	29.34	SE	SE., 10	SSE	SE., 10	SSE.-S.
Goodwood, Br. S. S.	Portland	Panama	19 58 N.	106 58 W.	18	2 a., 19	19	28.82	NW	SW., 12	SW	SW., 12	NW.-SW.
Robin Adair, Am. S. S.	San Pedro	Balboa	21 09 N.	107 33 W.	18	Midt., 18	19	28.96	NNW	W., 12	SSW	SW., 12	NNW.-W.-SW.
Maine, Am. S. S.	Balboa	San Pedro	19 56 N.	107 19 W.	17	8 a., 19	20	28.95	ESE	NW., 12	WSW	NW., 12	NW.-WNW.
Corinto, Am. S. S.	San Francisco	Cristobal	19 50 N.	105 35 W.	18	8 p., 18	20	29.46	E	E., 9	SE	E., 9	E.-SE.
Marenta, Br. S. S.	Canal Zone	Los Angeles	14 50 N.	97 05 W.	19		20	29.70	W	W., 8	NW	W., 8	
Vega, Am. S. S.	San Diego	Panama	19 36 N.	106 53 W.	19		20	28.98	ENE	WNW., 7	SE	SW., 10	
Manhattan Island, Am. S. S.	San Pedro	New Orleans	20 40 N.	108 00 W.	19	11 a., 20	20	29.67	SE	WNW., —	SE	N., 9	NE.-N.-NNW.
Maliko, Am. S. S.	Los Angeles	Charleston	20 44 N.	107 22 W.	19	2 p., 19	20	29.24	N	NE., 12	NW	NE., 12	E.-NE.-N.
Astral, Am. S. S.	New York	San Pedro	20 30 N.	107 59 W.	19	4 a., 20	20	29.54	S	SSW., 8	W	SW., 10	
California, Am. S. S.	San Francisco	New York	20 29 N.	107 02 W.	19	3 a., 20	20	28.73	E	E., 10	SE	SSW., 11	
Witell, Ger. S. S.	Colon	Los Angeles	14 41 N.	94 33 W.	20	10 p., 20	20		NW	NW., 8	W	NW., 8	NW.-W.
SOUTH PACIFIC OCEAN													
West Camargo, Am. S. S.	San Francisco	Buenos Aires	51 35 S.	76 14 W.	3	4 p., 3	6	29.36	NW	SSW., 7	WNW	WSW., 9	NW.-S.
D. G. Scofield, Am. S. S.	Buenos Aires	San Pedro	53 11 S.	73 45 W.	17	4 p., 17	19	29.53	NW	W., 10	NNW	WNW., 10	W.-WNW.
Waiotapu, Br. S. S.	Los Angeles	Wellington	37 50 S.	178 53 W.	23	Noon, 24	26	29.12	NW	WNW., —	SW	WNW., 10	NW.-W.-WSW.

NORTH PACIFIC OCEAN

By WILLIS E. HURD

It was noticeable in the latter part of September that a slight weakening was taking place in the North Pacific anticyclone. On the north the Gulf of Alaska extension of the Aleutian LOW was beginning to penetrate it more deeply as the month advanced. On the east, in the last decade, a low pressure-area of the winter type entered its boundaries and for two or three days lay off the California coast; and on the west an early winter type of cyclone encroached upon the HIGH, remaining in the neighborhood of Midway Island from the 26th to 28th, and giving moderate to strong gales in its western quadrants.

In higher latitudes the Aleutian cyclone showed signs of increasing development, especially to the eastward of the Alaskan Peninsula, where, for the first time since April, pressure had fallen below 29 inches on a given day. The center of this cyclone continued near Kodiak, where it had been located during most of the preceding months of the year.

Pressure data for several island and American coast stations are given in the following table:

TABLE 1.—*Averages, departures, and extremes of atmospheric pressure at sea level at indicated hours, North Pacific Ocean, September, 1928*

Stations	Average pressure	Departure from normal	Highest	Date	Lowest	Date
	Inches	*Inch*	*Inches*		*Inches*	
Dutch Harbor [1, 2]	29.85	+0.09	30.32	9th	29.22	11th.
St. Paul [1, 3]	29.82	+0.12	30.44	30th	29.08	6th.
Kodiak [1, 3]	29.66	−0.04	30.06	3d [6]	28.80	11th.
Midway Island [1]	30.00	−0.07	30.20	10th	29.68	27th.
Honolulu [4]	30.01	+0.01	30.09	1st	29.89	25th.
Juneau [4]	29.94	+0.02	30.32	6th	29.12	13th.
Tatoosh Island [4, 5]	30.04	+0.03	30.29	20th	29.71	11th.
San Francisco [4, 5]	29.94	0.00	30.18	30th	29.70	19th.
San Diego [4, 5]	29.87	+0.02	30.04	30th	29.63	19th.

[1] P. m. observations only.
[2] For 28 days.
[3] For 29 days.
[4] A. m. and p. m. observations.
[5] Corrected to 24-hour mean.
[6] Also on 26th.

In Asiatic waters atmospheric conditions were marked throughout the month by a great number of depressions, together with several active cyclones from oceanic and continental sources. A report of the typhoons in tropical waters by the Rev. José Coronas, S. J., is subjoined.

With the increase of cyclonic activity over the ocean since August, a slight increase occurred in the number and extent of gales, especially in middle latitudes, and during the last days of the month. Along the upper trans-Pacific steamship routes, however, the weather could not yet be called stormy as a whole, since the maximum force of the gales reported did not exceed 9, the heavier winds being confined to lower latitudes. Only one of our marine observing vessels yet heard from passed through the violent portion of a typhoon. This was the American steamer *Everett*, which sustained some damage in the Eastern Sea on the 13th from the same intense typhoon that devastated Shanghai on the following day.

In Mexican tropical waters three known cyclones, one a hurricane, occurred this month.

The earliest originated on the 1st not far from 14° N., 109° W., and moved in a west-northwesterly direction until the 3d, when it was lost to observation near 20° N., 121° W. The path of this cylcone lay close to, and for a part of the time between, the courses of two American steamers, the *Santa Isabel* and the *Chattanooga City*, which were en route from the Canal to Honolulu. The lowest observed pressure was 29.44 inches, read on board the *Santa Isabel* on the 3d, in 17° 52′ N., 117° 12′ W. The highest wind force, WSW., 10 plus, was reported by the *Chattanooga City* on the 2d in 16° 17′ N., 115° 50′50′ W.

On the 13th westerly to northwesterly gales of moderate force occurred south of the Gulf of Tehuantepec, but whether of the norther or of the cyclonic type is not now determined. Lowest observed pressure 29.78 inches.

On the 20th to 22d westerly to northwesterly winds of force 8 were met with in nearly the same location in conjunction with a known cyclonic disturbance which occasioned bad weather between Salina Cruz and Acapulco.

The hurricane of the month seems to have formed some 200 miles west-southwest of Acapulco on the 17th. It moved northwestward within a huge depression which covered most of the western coast region of Mexico, all of Lower California, and adjacent waters, and on the 18th and 19th caused hurricane winds over the lower waters of the Gulf of California south of Mazatlan. On the 20th whole gales occurred in nearly the same region, but on the 21st the cyclone, with much lessened intensity, curved northeastward and entered the coast above Mazatlan. It is interesting to note that it crossed Mexico in an east-northeast direction as a mere depression and entered the Gulf of Mexico below Brownsville on the 22d. For several days it disturbed the weather slightly over the western part of the gulf, but had disappeared by the end of the month.

Compared with its sudden great acceleration in speed overland, its rate of progression was extraordinarily slow on the 18th to 20th, when its average forward movement was scarcely more, perhaps, than 2 or 3 miles an hour. During this time at differing hours and places the directions of the hurricane winds seem to indicate that it had periods of retrogression and recovery, or that the center was quite elongated. The barometric depth of the storm was considerable, especially during the 18th and 19th, when it was below 29 inches. The minimum reading was 28.82 inches, made on board the British steamer *Goodwood* at 2 a. m. of the 19th, in 19° 58′ N., 106° 58′ W. The American steamer *Maine*, Balboa to San Pedro, entered the zone of hurricane velocities at 7 p. m. of the 18th—noon position 19° 08′ N., 106° 04′ W.—and left it at 5 p. m. of the 19th—noon position 19° 56′ N., 107° 19′ W.—the wind meanwhile changing from north-northwest into north and back through north into west, covering a period of 22 hours during which the vessel was in the heaviest of the storm. She experienced winds of gale force from late on the 17th until 1 a. m. of the 20th.

Reports of a number of vessels involved in the several cyclones off the Mexican coast are given in the table.

Up to the end of September 7 cyclones are known to have occurred in these waters this year—2 in June, 1 each in July and August, and 3 in September. Three of the number were hurricanes.

At Honolulu easterly trades prevailed on all but one day. They were stronger than usual for the month, the hourly velocity averaging 9.1 miles. The maximum velocity was at the rate of 24 miles, from the east, on the 5th.

The number of days with fog decreased over the western half of the upper sailing routes since August, but increased

over the eastern half, so that the frequency of formation was about the same in both regions, ranging from 10 to 25 per cent. Along the American coast fog was observed most frequently between Vancouver and Cape San Lucas, the highest percentage, 30 to 35, being between the thirtieth and fortieth parallels.

Whirlwind.—Mr. William J. Rae, third officer of the Canadian steamer *City of Victoria*, Capt. J. MacPhail, Pacific coast toward China, reports as follows:

Tuesday, September 25, 9:30 a. m., apparent time at ship in latitude 37° 50′ N., longitude 134° 30′ E., experienced a miniature tornado or whirlpool. It approached ship stern on from SW. ½ W. (true), about 150 feet diameter, visible on water below a patch of heavy A. Cu. clouds in squall form, all moving with anticlockwise motion. It passed from stern over ship off port quarter, turning ship 4 points off its course with helm hard against it. It moved approximately 6 to 8 miles per hour, spiraling in force of strong gale, breaking away lifeboat cover stops and lifting light timbers in deck cargo

TWO PACIFIC-CHINA AND ONE PACIFIC-JAPAN TYPHOONS IN SEPTEMBER, 1928

By Rev. José Coronas, S. J.

[Weather Bureau, Manila, P. I.]

The most important typhoons of the month of September were two that crossed the great portion of the Pacific from the Ladrone Islands to the China coast and then entered eastern China, and one that moved from the neighborhood of Guam to the central part of Japan. There was not a single well-developed typhoon over the Philippines during the whole month.

Two Pacific-China typhoons, August 26 to September 15.—The first of these typhoons was probably formed on August 26 to 27 to the SSW. of Guam near 143° longitude E. and 11° latitude N. It moved NNW. on the 27th and inclined westward on the 28th and 29th, while its rate of progress was much decreased during these two days. A practically west direction was kept by the typhoon on the 30th of August and 1st of September. In the afternoon of September 2, when the center was about 300 miles to the east of northern Luzon, the typhoon took a northwesterly direction toward Formosa, traversing the northern part of this island during the night of the 5th and early morning of the 6th. A new and very pronounced inclination of the track to the west was noticed on the Formosa Channel; but once in China, the typhoon recurved to the N. and N. by E. on the 7th, the center passing west and northwest of Shanghai in the morning of the 8th.

The approximate positions of the typhoon at 6 a. m. of September 1 to 8 were as follows:

September 1, 6 a. m. 132° 15′ longitude E., 16° 30′ latitude N.
September 2, 6 a. m. 128° 20′ longitude E., 16° 55′ latitude N.
September 3, 6 a. m. 126° 30′ longitude E., 17° 55′ latitude N.
September 4, 6 a. m. 124° 50′ longitude E., 20° 00′ latitude N.
September 5, 6 a. m. 122° 35′ longitude E., 22° 20′ latitude N.
September 6, 6 a. m. 121° 00′ longitude E., 24° 30′ latitude N.
September 7, 6 a. m. 117° 45′ longitude E., 25° 25′ latitude N.
September 8, 6 a. m. 117° 45′ longitude E., 30° 00′ latitude N.

The second Pacific-China typhoon was shown by our weather maps of the 5th and 6th to the northeast of Guam near 147° or 148° longitude E. and 16° latitude N. It moved northwestward until the 9th, when it began to incline to the west about 200 miles south of the Bonins. The steamer *Steel Scientist* was well under the influence of this typhoon to the southeast and south of the Bonins on the 8th and 9th, when very strong winds were experienced from the SE. and S. quadrants. The typhoon moved almost due W. on the 10th and 11th, WNW. and NW. on the 12th, and again westward on the 13th and morning of the 14th. Like the preceding one, it recurved to the north over eastern China and passed west of Shanghai during the night of the 14th. According to press dispatches, "following torrential rains, Shanghai was visited during this typhoon by floods the like of which had not been seen since 1905. Various parts of the international settlement and the French concession were under 18 inches of water. The rainfall during 24 hours was approximately 8 inches."

The approximate positions of the center during the period 8th to 15th were as follows:

September 8, 6 a. m. 142° 30′ longitude E., 22° 40′ latitude N.
September 9, 6 a. m. 141° 10′ longitude E., 23° 50′ latitude N.
September 10, 6 a. m. 137° 30′ longitude E., 25° 00′ latitude N.
September 11, 6 a. m. 134° 10′ longitude E., 25° 00′ latitude N.
September 12, 6 a. m. 130° 50′ longitude E., 25° 05′ latitude N.
September 13, 6 a. m. 125° 55′ longitude E., 27° 00′ latitude N.
September 14, 6 a. m. 122° 50′ longitude E., 28° 00′ latitude N.
September 15, 6 a. m. 119° 00′ longitude E., 32° 30′ latitude N.

The Pacific-Japan typhoon, September 18 to 25.—The first part of this typhoon is rather indefinite, although it is probable that it formed on the 18th to 19th to the southwest of Guam near 142° longitude E. and 11° latitude N. It moved probably N. or NNW. during the whole track from the 19th until it reached Japan to the west of Tokyo in the evening of the 24th. The center could be seen in our weather maps passing west of the Bonins in the afternoon of the 23d. The storm probably filled up on the 25th over the Japan Sea close to the western coast of Japan.

Besides these three well-developed typhoons, our weather maps showed during the month five other centers of depressions or typhoons over the Far East, but they were either typhoons of an indefinite track or depressions of little importance. There were 3 over the Pacific between the Ladrone Islands and the Philippines, 1 over the China Sea in the neighborhood of the Paracels, and 1 over the Balintang Channel and the southern part of Formosa.

CLIMATOLOGICAL TABLES[1]

CONDENSED CLIMATOLOGICAL SUMMARY

In the following table are given for the various sections of the climatological service of the Weather Bureau the monthly average temperature and total rainfall; the stations reporting the highest and lowest temperatures, with dates of occurrence; the stations reporting the greatest and least total precipitation; and other data as indicated by the several headings.

The mean temperature for each section, the highest and lowest temperatures, the average precipitation, and the greatest and least monthly amounts are found by using all trustworthy records available.

The mean departures from normal temperatures and precipitation are based only on records from stations that have 10 or more years of observations. Of course, the number of such records is smaller than the total number of stations.

Condensed climatological summary of temperature and precipitation, by sections, September, 1928

Section	Temperature								Precipitation					
	Section average	Departure from the normal	Monthly extremes						Section average	Departure from the normal	Greatest monthly		Least monthly	
			Station	Highest	Date	Station	Lowest	Date			Station	Amount	Station	Amount
	°F.	°F.		°F.			°F.		In.	In.		In.		In.
Alabama	73.7	-1.7	2 stations	98	[2] 14	St. Bernard	36	25	2.91	-0.36	Ozark	8.85	Dancy	0.18
Arizona	75.4	+1.5	Maricopa	115	17	Bright Angel Ranger Station.	25	14	0.46	-0.87	Bright Angel Ranger Station.	1.99	10 stations	0.00
Arkansas	70.5	-3.7	Texarkana	101	15	Dutton	32	24	0.45	-2.98	Wynne	2.60	12 stations	0.00
California	68.4	+0.8	Greenland Ranch	117	6	Helm Creek	16	30	0.06	-0.49	Crescent City	1.55	170 stations	0.00
Colorado	57.4	-0.2	Lamar	101	[2] 7	2 stations	12	[2] 14	0.49	-0.87	Auldhurst	2.20	3 stations	0.00
Florida	79.1	-0.3	2 stations	99	2	3 stations	48	25	11.61	+4.95	Hastings	20.82	Bluff Springs	4.75
Georgia	73.5	-1.8	2 stations	97	[2] 14	Clayton	34	26	7.10	+3.63	St. George	21.28	Griffin	1.37
Idaho	58.4	+1.5	Orofino	103	3	Obsidian	15	10	0.32	-0.74	Kooskia	2.07	7 stations	0.00
Illinois	63.1	-4.3	McLeansboro	98	13	Lincoln	22	26	2.14	-1.48	Jacksonville	6.05	3 stations	T.
Indiana	62.6	-4.4	Marengo	98	12	2 stations	22	26	1.26	-1.86	Rockville	3.81	Farmland	0.10
Iowa	60.5	-3.8	2 stations	93	9	4 stations	24	25	3.08	-0.59	Centerville	9.98	Sheldon	1.04
Kansas	67.7	-1.9	Hutchinson	102	8	Oberlin	27	25	1.36	-1.56	Leavenworth	5.32	Trousdale	0.00
Kentucky	65.6	-4.7	Middlesboro	99	10	Farmers	24	24	0.80	-2.01	7 stations	0.00	Whitesburg	4.04
Louisiana	75.9	-2.0	2 stations	100	[2] 8	Winnsboro	42	20	4.22	+0.26	Port Eads	11.97	Shreveport	0.38
Maryland-Delaware	63.3	-4.2	Millsboro, Del	93	13	Grantsville, Md	28	25	4.67	+1.41	Dover, Del	8.73	Oakland, Md	2.17
Michigan	55.9	-4.1	Cassopolis	93	14	3 stations	22	[2] 28	3.25	+0.05	Alpha	8.57	Gladwin	0.96
Minnesota	55.3	-3.1	Beardsley	91	13	Angus	20	26	2.93	-0.07	Reeds	6.02	Argyle	0.41
Mississippi	73.5	-2.8	2 stations	100	14	Tupelo	39	24	1.82	-1.23	Biloxi	7.40	Holly Springs	0.04
Missouri	65.0	-4.0	5 stations	95	[2] 9	2 stations	28	[2] 24	2.61	-1.12	Downing	9.04	2 stations	0.00
Montana	55.3	+0.3	2 stations	97	6	Outlook	8	26	0.34	-0.99	Darby	1.81	6 stations	0.00
Nebraska	62.4	-1.5	2 stations	103	[2] 7	Nenzel	17	27	1.22	-0.91	Falls City	6.26	Kowanda	0.00
Nevada	64.0	+1.9	Logandale	107	[2] 4	2 stations	16	[2] 9	0.01	-0.39	Smith	0.15	31 stations	0.00
New England	57.3	-2.8	Chestnut Hill, Mass	89	12	2 stations	23	[2] 25	3.99	+0.34	Kingston, R. I	7.76	Pittsfield, Mass	1.58
New Jersey	62.6	-2.8	Belvidere	90	13	2 stations	29	[2] 25	4.52	+0.95	Tuckerton	9.62	Culvers Lake	1.54
New Mexico	63.4	+0.8	Carlsbad	100	13	Selsor Ranch	12	14	0.58	-0.93	Fort Bayard	2.99	8 stations	0.00
New York	58.2	-2.9	Dansville	92	12	Gloversville	23	25	2.49	-0.96	Roslyn	5.34	Avon	0.40
North Carolina	67.8	-2.4	Kinston	98	13	Mount Mitchell	25	26	11.18	+6.99	Southern Pines	19.50	Asheville	4.85
North Dakota	53.9	-2.5	Arnegard	95	6	Berthold Agency	12	25	0.93	-0.71	Valley City	4.89	4 stations	T.
Ohio	61.6	-4.0	Middleport	96	14	Peebles	23	26	0.90	-2.15	Madison	2.64	Warren	0.14
Oklahoma	72.2	-1.6	4 stations	103	[2] 12	Goodwell	34	21	0.86	-2.36	Purcell	2.87	Waurika	0.10
Oregon	59.5	+0.8	Grants Pass	105	22	2 stations	15	[2] 9	0.85	-0.67	Valsetz	2.45	3 stations	T.
Pennsylvania	60.4	-3.6	Lykens	94	14	Gouldsboro	25	25	2.33	-1.15	Gettysburg	5.73	Beaver Falls	0.71
South Carolina	72.1	-2.9	Calhoun Falls	96	14	Caesars Head	38	[2] 26	12.53	+8.43	Marion	27.06	Greenville	3.94
South Dakota	59.3	-1.7	Bellefouche	98	6	Elm Springs	12	27	1.57	-0.14	Strool	4.99	Ottumwa	0.01
Tennessee	67.4	-3.8	2 stations	96	[2] 13	2 stations	30	[2] 24	2.80	-0.22	Pheasant Field	8.90	Lexington	0.00
Texas	75.7	-1.5	2 stations	106	[2] 1	Muleshoe	36	24	3.00	+0.12	Corpus Christi	15.89	5 stations	0.00
Utah	62.4	+1.9	St. George	105	2	Great Basin Exp. Sta., Alpine.	17	13	0.25	-0.78	Green River	1.04	8 stations	0.00
Virginia	64.3	-4.0	Winchester	95	13	Emory	27	26	6.86	+3.74	Diamond Springs	15.23	Dale Enterprise	2.96
Washington	58.0	+0.8	Wahluke	103	3	2 stations	22	20	0.78	-1.19	Wynoochee Oxbow	4.33	8 stations	0.00
West Virginia	61.3	-4.5	Point Pleasant	100	15	Pickens	24	26	2.71	-0.34	Organ Cave	6.45	New Cumberland	0.81
Wisconsin	56.1	-3.5	2 stations	89	[2] 8	Long Lake	19	28	4.14	+0.72	Florence	7.67	Lake Mills	1.01
Wyoming	54.7	0.0	Colony	97	6	South Pass City	12	21	0.51	-0.87	Upton	2.07	5 stations	0.00
Alaska (August)	50.3	-1.4	Rampart	87	24	Bonanza Mine	24	31	4.16	+0.02	Latouche	16.38	Barrow	0.39
Hawaii	74.8	+0.1	Kaanapali	94	[2] 16	Volcano Observatory	52	23	5.68	-0.24	Papaikou (Mauka)	28.95	4 stations	0.00
Porto Rico	79.6	+0.7	Rio Piedras	97	22	5 stations	62	2	14.14	+6.15	Adjuntas	43.48	Ensenada	4.00

[1] For description of tables and charts, see Review, January, 1928, p. 29.

[2] Other dates also.

TABLE 1.—*Climatological data for weather bureau stations, September, 1928*

District and station	Elevation of instruments: Barometer above sea level	Thermometer above ground	Anemometer above ground	Pressure: Station, reduced to mean of 24 hours	Sea level, reduced to mean of 24 hours	Departure from normal	Temperature of the air: Mean max. + mean min. ÷ 2	Departure from normal	Maximum	Date	Mean maximum	Minimum	Date	Mean minimum	Greatest daily range	Mean wet thermometer	Mean temperature of the dew-point	Mean relative humidity	Precipitation: Total	Departure from normal	Days with .01, or more	Wind: Total movement	Prevailing direction	Maximum velocity: Miles per hour	Direction	Date	Clear days	Partly cloudy days	Cloudy days	Average cloudiness, tenths	Total snowfall	Snow, sleet, and ice on ground at end of month
	Ft.	Ft.	Ft.	In.	In.	In.	°F.	°F.	°F.		°F.	°F.		°F.	°F.	°F.	°F.	%	In.	In.		Miles.								0-10	In.	In.
New England							58.8	−2.0										80	4.25	+1.1										6.1		
Eastport	76	67	85	29.95	30.03	0.00	54.4	−1.4	73	9	61	37	29	48	25	51	48	81	3.76	+1.0	12	5,616	s.	27	nw.	26	6	7	17	6.9	0.0	0.0
Greenville, Me	1,070	6	----	28.84	30.05	----	51.3	----	75	17	60	27	30	42	34	----	----	----	4.02	----	12	----	se.	----	----	----	5	10	15	----	0.0	0.0
Portland, Me	103	82	117	29.94	30.06	+.01	57.2	−2.4	79	11	65	37	29	50	26	53	49	79	3.86	+0.8	13	4,829	n.	24	nw.	26	10	5	15	6.1	0.0	0.0
Concord	289	70	79	29.73	30.04	−.02	56.4	−2.9	83	17	67	29	29	46	34	----	----	----	2.41	−1.0	11	2,977	nw.	16	nw.	26	8	10	12	6.0	0.0	0.0
Burlington	403	11	48	29.58	30.02	−.04	56.0	−4.3	82	13	65	32	24	47	33	----	----	----	2.52	−1.0	13	5,869	s.	33	se.	20	6	9	15	6.7	0.0	0.0
Northfield	876	12	60	----	30.06	.00	52.6	−3.5	80	13	64	26	25	41	37	----	----	90	3.96	+1.2	12	3,374	s.	18	se.	15	3	12	15	7.3	0.0	0.0
Boston	125	115	188	29.91	30.05	−.02	62.4	−0.8	85	13	70	42	27	55	29	56	52	76	4.47	+1.3	5	5,369	sw.	24	w.	26	7	14	9	6.0	0.0	0.0
Nantucket	12	14	90	30.03	30.04	−.04	62.6	−0.2	80	4	68	45	27	57	17	58	55	80	6.98	+4.2	14	9,610	sw.	48	ne.	19	7	10	13	6.5	0.0	0.0
Block Island	26	11	46	30.00	30.03	−.05	62.4	−1.0	76	13	67	46	29	58	13	58	54	77	7.50	+4.8	8	10,682	w.	52	ne.	19	7	14	9	5.6	0.0	0.0
Providence	160	215	251	29.88	30.05	−.02	61.2	−2.0	82	13	69	40	29	53	25	56	52	76	3.25	+0.1	10	6,435	nw.	35	nw.	26	10	10	10	5.6	0.0	0.0
Hartford	159	122	----	29.89	30.06	−.01	60.5	−1.2	84	13	69	39	27	52	28	----	----	----	4.20	+0.7	14	----	ne.	----	----	----	9	10	11	5.5	0.0	0.0
New Haven	106	74	153	29.94	30.05	−.02	61.7	−1.8	84	13	70	40	29	54	27	57	54	79	3.85	+0.3	10	5,360	ne.	26	ne.	19	10	13	7	5.3	0.0	0.0
Middle Atlantic States							63.9	−2.9										79	4.76	+1.6										5.9		
Albany	97	102	115	29.94	30.04	−.03	61.0	−2.1	88	13	70	38	29	52	26	54	51	77	2.47	−0.6	9	4,517	sw.	32	sw.	20	13	12	5	4.3	0.0	0.0
Binghamton	871	10	84	29.11	30.04	−.03	59.7	−1.6	87	12	70	33	29	49	32	----	----	----	0.79	−2.0	10	3,431	ne.	20	sw.	20	6	13	11	5.8	0.0	0.0
New York	314	414	454	29.73	30.06	−.02	63.8	−3.0	84	13	70	43	27	58	21	58	54	74	3.36	0.0	11	9,144	nw.	43	nw.	26	7	13	10	6.2	0.0	0.0
Bellefonte	1,050	5	36	28.95	30.06	----	57.4	----	84	10	68	30	25	46	37	53	51	84	0.99	----	10	----	----	----	----	----	----	----	----	5.8	0.0	0.0
Harrisburg	374	94	104	29.66	30.06	−.02	62.4	−3.4	86	16	70	40	27	55	30	56	53	77	2.86	0.0	11	3,624	nw.	19	ne.	19	7	12	11	6.3	0.0	0.0
Philadelphia	114	123	341	29.94	30.07	−.01	65.4	−2.6	86	13	72	44	27	59	22	59	55	73	3.61	+0.5	9	6,973	sw.	48	ne.	19	6	11	13	6.3	0.0	0.0
Reading	325	81	98	29.71	30.06	----	63.2	----	88	12	71	41	26	55	30	56	53	74	3.19	−0.5	11	3,569	sw.	24	ne.	19	9	9	12	5.8	0.0	0.0
Scranton	805	111	119	29.20	30.06	−.01	60.0	−2.9	86	12	69	34	25	51	31	54	51	78	1.82	−1.0	14	4,174	s.	27	ne.	19	5	11	14	6.7	0.0	0.0
Atlantic City	52	37	172	29.98	30.04	−.03	65.6	−1.2	82	9	71	44	25	60	24	61	58	80	9.16	+6.5	11	11,134	s.	72	ne.	19	10	8	12	5.5	0.0	0.0
Cape May	17	13	49	----	----	----	65.0	−4.0	82	13	72	43	27	58	21	62	60	84	6.72	----	11	----	n.	----	----	----	9	7	14	----	0.0	0.0
Sandy Hook	22	10	55	30.02	30.04	----	64.6	----	83	13	70	45	27	60	20	59	55	75	4.08	----	10	9,698	sw.	52	ne.	19	7	8	15	6.1	0.0	0.0
Trenton	190	159	183	29.85	30.05	----	63.3	----	86	13	71	41	27	56	26	58	55	79	3.42	−0.2	9	6,379	sw.	39	ne.	19	7	9	14	6.3	0.0	0.0
Baltimore	123	100	215	29.92	30.05	−.03	65.8	−2.7	91	13	73	43	26	59	29	60	56	76	4.35	+1.0	11	6,184	sw.	47	ne.	19	8	6	16	6.3	0.0	0.0
Washington	112	62	85	29.93	30.05	−.03	64.9	−3.2	89	13	73	41	25	57	28	59	57	82	4.29	+1.0	11	3,296	nw.	24	se.	19	8	8	14	6.4	0.0	0.0
Cape Henry	18	8	54	30.00	30.02	----	69.6	----	83	12	76	48	27	64	23	66	64	83	8.90	+6.0	14	7,772	se.	62	ne.	19	9	9	12	5.9	0.0	0.0
Lynchburg	681	153	188	29.31	30.05	−.03	64.8	−4.2	89	14	74	39	27	56	30	59	57	82	6.01	+2.7	12	3,610	ne.	35	ne.	19	7	10	13	6.3	0.0	0.0
Norfolk	91	170	205	29.94	30.04	−.02	69.8	−1.8	89	13	77	50	27	63	22	64	61	81	9.79	+6.6	14	6,936	ne.	53	ne.	18	11	4	15	6.0	0.0	0.0
Richmond	144	11	52	29.90	30.05	−.02	65.8	−4.7	88	13	74	42	25	58	26	61	59	85	7.01	+3.8	11	4,155	ne.	33	ne.	19	13	4	13	5.7	0.0	0.0
Wytheville	2,304	49	55	27.70	30.05	−.02	60.2	−3.4	85	14	70	35	25	51	33	55	53	85	5.06	+1.8	11	2,780	w.	23	w.	25	7	12	11	5.5	0.0	0.0
South Atlantic States							72.2	−1.2										84	12.14	+7.9										5.7		
Asheville	2,253	70	84	27.72	30.04	−.03	63.5	−1.5	85	14	73	38	27	54	31	57	55	84	4.85	+2.0	12	3,665	nw.	21	n.	25	11	10	9	5.0	0.0	0.0
Charlotte	779	55	62	29.20	30.03	−.04	68.8	−2.7	92	13	78	47	25	60	29	64	62	85	11.13	+8.1	13	2,705	ne.	22	ne.	18	13	6	11	5.3	0.0	0.0
Hatteras	11	11	50	30.00	30.01	−.05	73.9	−0.6	86	6	79	50	27	68	23	70	68	82	17.55	+12.9	16	7,655	ne.	40	sw.	19	11	10	9	5.2	0.0	0.0
Raleigh	376	103	110	29.63	30.03	−.04	67.6	−3.5	89	13	76	47	25	60	27	63	61	84	11.92	+8.6	10	3,965	ne.	33	ne.	18	9	7	14	5.9	0.0	0.0
Wilmington	78	81	91	29.94	30.02	−.03	73.4	+0.3	92	14	81	53	25	66	22	69	67	88	13.41	+8.9	13	3,756	n.	24	se.	18	9	8	13	6.2	0.0	0.0
Charleston	48	11	92	29.94	29.99	−.05	75.8	−0.8	92	14	82	58	25	70	21	72	71	88	14.30	+9.8	17	6,445	ne.	59	e.	18	4	12	14	6.6	0.0	0.0
Columbia, S. C	351	41	57	29.64	30.01	−.04	73.0	−1.5	92	14	81	51	25	65	28	66	64	81	14.64	+11.2	12	3,833	ne.	33	n.	18	10	11	9	5.4	0.0	0.0
Due West	711	10	55	29.28	30.05	----	70.1	----	91	14	79	46	25	61	31	----	----	----	4.03	----	12	4,727	ne.	40	ne.	18	15	6	9	5.0	0.0	0.0
Greenville, S. C	1,039	139	146	28.94	30.02	----	69.8	−0.8	91	14	78	48	25	61	27	63	60	78	3.94	----	10	4,648	ne.	36	ne.	18	13	8	9	5.0	0.0	0.0
Augusta	182	62	77	29.80	30.00	−.05	74.7	−0.6	95	14	84	53	25	66	29	68	66	82	7.47	+4.1	9	3,101	nw.	37	n.	18	9	10	11	5.6	0.0	0.0
Savannah	65	150	194	29.92	29.99	−.04	75.8	−0.4	91	13	83	60	25	69	21	70	69	86	16.87	+11.5	14	6,681	ne.	52	nw.	18	8	6	16	6.5	0.0	0.0
Jacksonville	43	209	245	29.92	29.97	−.03	77.5	−0.8	92	3	84	63	25	71	17	72	70	84	9.25	+1.9	13	7,149	ne.	48	e.	17	5	14	11	6.2	0.0	0.0
Florida Peninsula							80.9	+0.2										82	11.73	+4.1										7.0		
Key West	22	10	64	29.90	29.92	−.02	82.3	+0.1	90	25	88	73	10	77	15	77	75	81	8.13	+1.4	21	7,184	e.	39	w.	17	4	14	12	6.4	0.0	0.0
Miami	25	71	79	29.91	29.94	----	80.4	+0.3	88	6	86	70	3	75	17	76	74	81	17.00	+8.3	21	7,442	e.	60	w.	16	2	7	21	7.8	0.0	0.0
Tampa	35	79	87	29.90	29.94	−.03	80.0	+0.1	94	6	87	68	25	73	19	74	72	85	10.07	+2.7	19	4,062	ne.	31	n.	17	4	9	17	6.9	0.0	0.0
Titusville	44	5	----	29.90	29.95	----	----	----	92	6	86	----	----	----	----	----	----	----	13.36	----	15	----	e.	----	----	----	3	9	18	6.8	0.0	0.0
East Gulf States							74.6	−1.1										78	3.33	−0.5										5.1		
Atlanta	1,173	190	216	28.80	30.03	−.02	71.4	−1.0	91	14	80	48	24	63	30	62	58	70	3.16	+0.2	8	5,093	nw.	24	nw.	18	11	10	9	5.1	0.0	0.0
Macon	370	78	87	29.62	30.01	−.02	73.3	−1.5	91	14	82	46	25	64	35	68	66	84	3.73	+0.3	10	3,139	nw.	26	nw.	18	12	4	14	5.4	0.0	0.0
Thomasville	273	49	58	29.69	29.98	−.03	76.3	−0.5	92	14	84	52	25	68	30	70	68	86	8.02	+3.8	14	2,647	ne.	24	n.	17	7	8	15	6.8	0.0	0.0
Apalachicola	36	42	49	29.92	29.97	----	77.1	----	88	1	82	58	25	72	19	73	71	84	6.21	----	12	5,282	ne.	35	ne.	17	11	7	12	5.7	0.0	0.0
Pensacola	56	149	185	29.92	29.98	−.01	77.0	−1.0	89	15	82	62	25	72	17	70	68	78	6.71	+1.4	12	7,261	ne.	31	s.	12	11	4	15	5.6	0.0	0.0
Anniston	741	9	57	29.26	30.05	+.02	71.2	−0.1	92	15	83	39	25	59	41	----	----	----	0.83	−2.7	5	2,023	n.	14	n.	18	17	6	7	3.9	0.0	0.0
Birmingham	700	11	48	29.28	30.04	+.01	73.0	−1.8	93	16	84	46	24	62	36	63	59	72	1.82	−1.7	3	2,966	n.	17	n.	16	15	8	7	4.2	0.0	0.0
Mobile	57	125	161	29.92	29.98	−.02	77.2	−0.9	93	15	85	55	25	69	27	70	68	82	4.65	−0.4	11	5,372	n.	27	n.	17	11	8	11	5.5	0.0	0.0
Montgomery	223	100	112	29.76	30.01	−.01	75.6	−0.7	93	15	85	51	25	66	31	67	64	75	2.61	−0.4	10	3,331	ne.	22	ne.	17	13	6	11	5.1	0.0	0.0
Corinth	469	6	----	----	----	----	71.5	----	94	14	85	43	24	58	40	----	----	----	0.62	----	1	----	n.	----	----	----	10	19	1	----	0.0	0.0
Meridian	375	87	95	29.62	30.01	−.01	73.2	−1.3	91	14	84	46	25	63	37	65	61	74	1.04	−2.4	2	2,773	ne.	14	n.	17	15	8	7	4.0	0.0	0.0
Vicksburg	247	65	73	29.75	30.03	+.01	73.7	−2.6	93	12	83	53	19	64	20	65	61	73	0.27	−2.6	6	3,469	n.	15	ne.	24	15	8	7	4.1	0.0	0.0
New Orleans	53	76	84	29.92	29.97	+.01	78.4	−0.8	92	16	85	62	25	72	20	71	69	79	3.85	−1.2	10	4,661	ne.	19	ne.	23	8	10	12	5.9	0.0	0.0
West Gulf States							75.5	−1.6										73	4.51	+1.0										4.5		
Shreveport	249	77	93	29.75	30.02	+.02	75.4	−1.5	94	13	86	52	24	65	28	65	60	68	0.38	−2.4	5	3,213	ne.	18	ne.	15	18	5	7	3.6	0.0	0.0
Bentonville	1,303	11	44	28.69	30.04	+.02	66.7	−2.2	89	13	79	40	24	54	34	----	----	----	0.43	----	3	----	s.	----	----	----	29	1	0	----	0.0	0.0
Fort Smith	457	79	94	29.55	30.03	+.02	71.9	−2.5	96	12	84	47	24	60	32	61	55	64	0.05	−2.9	1	4,077	e.	17	nw.	29	19	8	3	2.8	0.0	0.0
Little Rock	357	136	153	29.67	30.04	+.01	71.6	−2.5	91	13	81	49	24	62	28	62	56	64	0.52	−2.7	1	4,673	ne.	20	n.	18	20	6	4	2.6	0.0	0.0
Austin	605	136	148	29.35	29.98	----	77.1	−1.2	96	30	87	57	20	67	33	67	63	71	4.36	+1.0	12	4,211	ne.	28	se.	16	11	7	12	5.4	0.0	0.0
Brownsville	57	53	61	29.83	29.93	----	78.7	−0.8	95	2	87	66	24	73	21	73	72	85	8.91	+3.4	12	4,343	n.	19	nw.	23	10	8	12	5.3	0.0	0.0
Corpus Christi	20	11	78	29.92	29.94	−.01	79.8	+0.1	93	30	86	66	23	74	21	74	72	83	15.89	+11.9	16	7,151	n.	30	n.	23	10	4	16	6.0	0.0	0.0
Dallas	512	220	227	29.47	30.01	----	76.0	----	93	29	86	56	30	66	35	----	----	----	0.44	----	5	6,387	se.	23	ne.	9	19	6	5	2.9	0.0	0.0
Fort Worth	670	106	114	29.30	30.00	+.01	76.2	−0.7	98	14	86	56	30	66	34	65	59	62	0.45	−2.0	5	4,537	se.	24	se.	8	14	8	8	4.5	0.0	0.0
Galveston	54	106	114	29.92	29.99	.00	79.8	−2.1	90	30	83	63	30	73	17	75	72	81	7.20	+1.6	10	5,845	ne.	26	se.	21	14	6	10	4.8	0.0	0.0
Groesbeck	461	11	56	29.51	29.99	----	76.4	----	96	14	88	54	20	65	36	----	----	----	1.03	----	6	5,056	ne.	27	n.	22	14	7	9	4.2	0.0	0.0
Houston	138	292	314	29.83	29.97	----	76.4	−2.6	94	30	84	58	24	69	24	----	----	----	6.18	+2.4	11	7,197	ne.	37	ne.	21	13	6	11	5.4	0.0	0.0
Palestine	510	64	72	29.48	30.00	+.01	75.2	−1.8	93	14	85	53	24	65	31	66	61	70	0.90	−2.0	5	3,627	ne.	17	se.	15	14	7	9	4.2	0.0	0.0
Port Arthur	34	58	66	29.80	29.94	----	75.1	----	94	30	84	59	24	70	31	71	68	82	4.20	----	8	4,966	ne.	19	e.	26	12	5	13	5.2	0.0	0.0
San Antonio	693	119	132	29.25	29.96	.00	77.4	−2.5	95	13	85	57	23	69	26	68	64	71	6.30	+3.2	10	4,193	ne.	20	ne.	22	10	10	10	5.4	0.0	0.0
Taylor	583	55	63	29.41	30.02	+.05	76.5	−0.4	95	13	86	57	24	67	31	----	----	----	3.00	0.0	9	4,094	n.	25	se.	16	13	8	9	4.6	0.0	0.0

TABLE 1.—*Climatological data for weather bureau stations, September, 1928*—Continued

District and station	Elevation of instruments: Barometer above sea level	Elevation of instruments: Thermometer above ground	Elevation of instruments: Anemometer above ground	Pressure: Station, reduced to mean of 24 hours	Pressure: Sea level, reduced to mean of 24 hours	Pressure: Departure from normal	Temperature: Mean max. + mean min. ÷ 2	Temperature: Departure from normal	Temperature: Maximum	Temperature: Date	Temperature: Mean maximum	Temperature: Minimum	Temperature: Date	Temperature: Mean minimum	Temperature: Greatest daily range	Mean wet thermometer	Mean temperature of the dew-point	Mean relative humidity	Precipitation: Total	Precipitation: Departure from normal	Precipitation: Days with .01, or more	Wind: Total movement	Wind: Prevailing direction	Wind: Maximum velocity: Miles per hour	Wind: Maximum velocity: Direction	Wind: Maximum velocity: Date	Clear days	Partly cloudy days	Cloudy days	Average cloudiness, tenths	Total snowfall	Snow, sleet, and ice on ground at end of month
	Ft.	Ft.	Ft.	In.	In.	In.	°F.	°F.	°F.		°F.	°F.		°F.	°F.	°F.	°F.	%	In.	In.		Miles.								0-10	In.	In.
Ohio Valley and Tennessee							64.9	−3.8										70	1.26	−1.6										4.3		
Chattanooga	762	190	215	29.23	30.03	−0.03	69.2	−3.0	90	15	79	43	25	59	34	61	57	73	3.32	+0.2	6	3,379	ne.	25	n.	18	16	9	5	4.3	0.0	0.0
Knoxville	995	102	111	29.01	30.06	.00	67.0	−3.6	90	14	77	42	26	58	32	60	57	78	3.02	+0.3	7	3,072	n.	19	n.	18	12	8	10	5.2	0.0	0.0
Memphis	399	76	97	29.62	30.04	+.01	71.0	−2.6	92	13	80	46	24	62	26	61	56	64	0.06	−2.7	1	3,873	ne.	19	n.	15	21	8	1	2.7	0.0	0.0
Nashville	546	168	191	29.49	30.07	+.01	68.5	−3.3	90	13	80	42	24	58	35	59	52	64	0.68	−2.7	2	4,538	ne.	28	ne.	18	13	15	2	3.9	0.0	0.0
Lexington	989	193	230	29.04	30.08	+.01	64.2	−4.3	88	14	74	36	24	55	27				0.71	−1.7	3	6,790	sw.	31	nw.	25	20	7	3	3.0	0.0	0.0
Louisville	525	188	234	29.50	30.08	+.02	65.8	−4.7	90	14	76	39	26	56	31	57	51	66	0.78	−2.0	3	5,608	n.	29	ne.	18	16	11	3	3.5	0.0	0.0
Evansville	431	76	116	29.62	30.09	+.03	67.2	−3.5	91	13	78	39	26	56	27	57	51	63	0.25	−3.1	5	4,853	s.	22	nw.	23	16	12	2	3.3	0.0	0.0
Indianapolis	822	194	230	29.19	30.07	+.01	63.0	−3.9	88	14	73	36	24	53	26	54	48	65	0.92	−2.5	7	6,442	s.	29	w.	25	15	13	2	3.5	0.0	0.0
Royal Center	736	11	55	29.27	30.07		59.8		87	9	72	30	26	48	34				0.57		7	5,663	sw.	30	w.	14	12	11	7	4.6	0.0	0.0
Terre Haute	575	96	129	29.44	30.06		63.5		90	9	74	34	26	53	28	55	51	73	2.27		9	5,243	sw.	25	nw.	25	12	13	5	4.3	0.0	0.0
Cincinnati	627	11	51	29.40	30.08	+.01	63.8	−3.3	92	14	75	33	26	52	33	55	50	69	1.27	−1.4	5	3,928	sw.	22	sw.	25	18	9	3	3.8	0.0	0.0
Columbus	822	179	222	29.20	30.07	.00	62.5	−4.0	89	14	72	35	26	53	30	54	49	67	0.80	−1.8	6	5,815	s.	35	w.	25	15	11	4	4.2	0.0	0.0
Dayton	899	137	173	29.11	30.06		63.4	−3.2	90	14	74	35	26	53	31	54	48	65	0.73	−2.2	8	5,315	sw.	28	w.	25	8	17	5	4.8	0.0	0.0
Elkins	1,947	59	67	28.04	30.09	+.01	58.4	−4.6	84	10	68	33	26	49	32	53	51	87	2.34	−0.5	10	2,652	w.	18	nw.	25	6	11	13	6.6	0.0	0.0
Parkersburg	637	77	82	29.43	30.09	+.01	63.5	−3.8	89	14	73	38	26	54	33	55	52	74	1.67	−1.0	6	3,041	se.	23	nw.	25	11	8	11	5.6	0.0	0.0
Pittsburgh	842	353	410	29.15	30.06	−.02	61.2	−5.2	86	10	70	35	26	53	28	54	50	70	1.02	−1.6	6	6,351	sw.	31	nw.	25	9	12	9	5.7	0.0	0.0
Lower Lake Region							59.9	−3.1										72	1.92	−1.0										5.2		
Buffalo	767	247	280	29.19	30.02	−.04	59.0	−3.4	77	15	66	35	26	52	22	54	51	77	3.07	+0.2	14	10,541	sw.	44	w.	25	8	17	5	5.1	0.0	0.0
Canton	448	10	61	29.53	30.01		54.8	−4.5	78	15	64	34	29	45	39				2.36	−0.4	14	5,721	sw.	30	w.	13	10	12	8	5.0	0.0	0.0
Ithaca	836	5	100	29.12	30.03		58.0		86	12	68	34	29	48	37	52	50	79	1.22	−1.8	8	5,208	nw.	29	se.	20	6	14	10	6.1	0.0	0.0
Oswego	335	76	91	29.65	30.02	−.04	58.7	−2.5	85	12	66	38	27	51	28	54	50	74	2.68	0.0	11	5,625	s.	23	w.	13	5	16	9	6.0	0.0	0.0
Rochester	523	86	102	29.46	30.03	−.03	59.4	−3.0	87	10	68	38	26	51	33	53	49	70	0.75	−1.7	10	4,688	sw.	24	sw.	13	4	18	8	6.3	0.0	0.0
Syracuse	596	97	113	29.40	30.04	−.03	58.5	−3.1	84	12	66	36	26	51	34				2.28	−0.5	11	6,559	s.	34	nw.	22	5	17	8	5.8	0.0	0.0
Erie	714	130	166	29.26	30.03	−.03	60.8	−2.8	87	10	68	39	25	54	25	55	52	76	3.43	0.0	12	8,610	s.	36	n.	19	9	14	7	4.9	T.	0.0
Cleveland	762	190	201	29.23	30.05	−.01	61.6	−2.3	88	10	69	36	26	54	25	54	48	66	1.21	−2.1	9	8,049	sw.	40	nw.	25	9	13	8	5.1	0.0	0.0
Sandusky	629	5	67	29.38	30.06	.00	62.7	−2.6	92	10	73	34	26	53	30				0.73	−2.2	9	5,502	sw.	25	nw.	21	9	18	3	4.8	0.0	0.0
Toledo	628	208	243	29.38	30.06	.00	61.4	−3.0	87	10	71	37	26	52	29	54	49	70	1.66	−1.1	7	8,306	sw.	33	sw.	15	17	11	2	3.4	0.0	0.0
Fort Wayne	856	113	124	29.12	30.05		61.4	−4.1	89	9	72	32	26	51	29	53	48	69	0.56		4	5,487	sw.	30	w.	14	11	12	7	4.5	0.0	0.0
Detroit	730	218	258	29.26	30.05	−.01	60.8	−2.7	86	10	69	35	26	53	25	53	48	70	1.68	−1.2	8	6,598	sw.	31	sw.	24	10	11	9	5.0	0.0	0.0
Upper Lake Region							55.8	−3.7										79	3.18	−0.1										5.4		
Alpena	609	13	92	29.34	30.01	−.02	53.3	−4.3	82	8	62	31	24	44	30	50	47	84	3.71	+0.7	17	6,656	sw.	29	w.	21	6	12	12	6.1	0.0	0.0
Escanaba	612	54	60	29.31	29.98	−.03	52.6	−4.5	77	8	60	31	25	45	24	49	47	85	4.78	+1.5	10	6,021	s.	28	nw.	22	8	11	11	5.5	T.	0.0
Grand Haven	632	54	89	29.34	30.01	−.03	58.0	−2.9	84	14	66	37	28	50	25	54	50	77	2.81	−0.8	9	6,877	sw.	36	w.	21	9	14	7	5.1	T.	0.0
Grand Rapids	707	70	87	29.26	30.03	−.02	59.6	−3.1	88	10	69	38	28	50	29	53	48	73	3.14	−0.4	13	3,347	nw.	18	w.	27	7	8	15	6.1	T.	0.0
Houghton	668	64	99	29.22	29.95	−.05	52.2	−4.7	79	6	59	34	24	45	28				4.08	+0.5	15	6,636	w.	30	e.	14	7	6	17	6.6	3.8	0.0
Lansing	878	6	49	29.09	30.04		56.8	−4.6	85	10	67	32	26	46	28	52	50	87	2.14	−0.8	13	2,854	sw.	15	w.	27	11	13	6	4.6	0.1	0.0
Ludington	637	60	66	29.31	30.00		56.9		79	14	64	36	29	50	25	52	49	78	1.94		9	6,647	s.	36	s.	22	10	13	7	4.6	0.0	0.0
Marquette	734	77	111	29.17	29.97	−.03	53.2	−4.3	79	8	60	34	23	46	29	48	45	79	4.31	+1.1	14	6,537	w.	30	s.	30	7	7	16	6.6	0.9	0.0
Port Huron	638	70	120	29.33	30.02	−.04	58.2	−3.4	85	10	67	32	26	50	27	53	49	77	1.37	−1.4	12	6,575	sw.	30	nw.	24	8	16	6	4.6	0.0	0.0
Sault Sainte Marie	614	11	52	29.30	29.99	−.03	52.0	−3.5	76	8	59	34	24	45	30	48	45	84	5.47	+2.0	17	5,106	nw.	33	nw.	21	5	8	17	7.2	0.1	0.0
Chicago	673	7	131	29.32	30.04	.00	61.4	−3.8	88	14	70	35	26	53	27	54	50	72	1.87	−1.3	6	6,263	sw.	28	sw.	24	16	10	4	3.6	T.	0.0
Green Bay	617	109	141	29.33	29.99	−.03	56.6	−3.8	80	8	66	32	26	47	29	51	47	78	2.34	−0.8	8	6,597	s.	34	s.	14	8	9	13	6.0	T.	0.0
Milwaukee	681	125	221	29.28	30.02	−.01	60.2	−2.3	87	10	69	34	26	52	25	52	48	70	1.50	−1.8	7	8,279	w.	36	s.	14	17	6	7	3.9	0.0	0.0
Duluth	1,133	5	47	28.75	29.97	−.01	51.6	−3.5	76	1	60	28	23	43	27	47	45	87	3.86	+0.6	15	7,918	nw.	36	nw.	20	9	10	11	5.7	0.3	0.0
North Dakota							54.4	−2.8										66	1.00	−0.5										4.1		
Moornead	940	50	58	28.95	29.97	+.01	54.8	−3.4	83	6	66	29	26	44	40	48	43	72	2.28	+0.1	8	5,260	nw.	25	e.	13	9	11	10	5.2	0.0	0.0
Bismarck	1,674	8	57	28.21	29.99	+.05	56.2	−1.9	90	6	69	23	25	43	51	47	39	62	1.15	−0.1	6	5,501	nw.	29	n.	15	14	10	6	3.9	0.0	0.0
Devils Lake	1,478	11	44	28.40	29.97	+.03	52.8	−3.1	87	6	66	20	26	40	43	45	38	68	0.27	−1.1	6	5,561	nw.	25	n.	24	15	8	7	3.9	0.0	0.0
Ellendale	1,457	10	56	28.42	29.99		54.8		86	7	67	25	25	42	40				2.35		7	8,262	nw.	45	nw.	15	15	10	5	3.9	0.0	0.0
Grand Forks	833	12	67				53.2		86	7	65	24	26	41	42	47			0.88		10		nw.		s.	18	11	10	9	4.5	T.	0.0
Williston	1,878	41	48	28.02	30.00	+.07	53.7	−2.9	93	6	68	17	25	39	48	44	36	60	0.31	−0.8	4	4,268	nw.	30	w.	7	18	8	4	3.1	0.0	0.0
Upper Mississippi Valley							61.6	−3.5										72	2.48	−1.0										3.8		
Minneapolis	918	102	208	28.98	29.96		58.3	−3.1	81	1	68	34	23	49	31				2.17	−1.0	8	7,888	s.	36	s.	19	10	10	10	5.1	T.	0.0
St. Paul	837	236	261	29.07	29.97	−.02	57.2	−4.1	79	1	67	31	26	48	30				2.04	−1.0	9	8,193	se.	36	nw.	22	12	9	9	4.7	T.	0.0
La Crosse	714	11	48	29.23	30.00	−.01	58.5	−2.8	82	8	68	31	26	48	28	52	50	80	4.73	+0.7	8	2,605	s.	14	sw.	14	13	9	8	5.0	T.	0.0
Madison	974	70	78	28.98	30.03	.00	59.0	−3.4	80	8	65	34	26	50	25	52	47	72	1.78	−1.9	8	4,968	sw.	20	nw.	22	17	8	5	3.5	T.	0.0
Wausau	1,247	4		28.66	29.99		55.0		77	8	65	30	28	45	33				5.64		11		w.				13	6	11	4.9	T.	0.0
Charles City	1,015	10	51	28.95	30.03	+.03	58.0	−3.0	87	9	69	32	26	47	32	52	48	77	2.01	−0.8	9	3,872	se.	19	w.	14	18	9	3	3.1	0.0	0.0
Davenport	606	71	79	29.38	30.04	+.01	62.6	−3.0	88	9	73	36	25	52	30	54	49	70	1.93	−1.6	7	3,688	nw.	18	s.	14	16	9	5	3.5	0.0	0.0
Des Moines	861	84	97	29.11	30.02	.00	62.0	−3.6	89	9	73	34	26	51	33	54	49	70	1.87	−1.8	10	4,123	s.	21	sw.	10	18	6	6	3.7	0.0	0.0
Dubuque	700	81	96	29.28	30.03	.00	59.8	−4.2	82	8	70	33	26	50	27	52	48	72	1.27	−2.7	5	3,487	s.	19	se.	12	16	9	5	3.9	0.0	0.0
Keokuk	614	64	78	29.38	30.06	+.03	63.1	−4.4	93	9	74	35	26	53	30	55	50	68	4.18	+0.3	9	3,930	s.	27	nw.	2	18	5	7	3.5	0.0	0.0
Cairo	358	87	93	29.69	30.07	+.02	68.2	−3.3	90	13	78	43	26	59	26	59	54	67	0.14	−2.8	1	4,614	s.	25	n.	23	17	10	3	3.3	0.0	0.0
Peoria	609	11	45	29.40	30.07	+.03	61.2	−3.1	89	9	73	29	26	50	33	54	51	79	3.18	−0.8	9	3,114	s.	19	w.	14	20	6	4	2.9	0.0	0.0
Springfield, Ill.	636	10	91	29.38	30.05	.00	64.0	−3.6	93	9	74	35	26	53	31	56	53	75	3.35	−0.3	9	4,617	s.	22	n.	23	19	5	6	3.4	0.0	0.0
Hannibal	534	74	109	29.49	30.06	+.03	63.0	−4.7	93	9	74	32	26	52	33				4.42	+0.9	9	4,638	sw.	35	nw.	12	18	5	7	3.6	0.0	0.0
St. Louis	568	265	303	29.46	30.06	+.02	67.4	−2.7	93	13	77	43	24	58	25	57	50	62	1.70	−1.8	8	7,037	sw.	36	sw.	14	16	12	2	2.9	0.0	0.0
Missouri Valley							63.6	−2.4										61	1.74	−1.1										3.1		
Columbia, Mo.	784	6	84	29.23	30.06	+.03	63.8	−4.4	92	9	76	37	26	52	32				3.33	+0.5	6	4,001	se.	29	nw.	12	20	6	4	3.0	0.0	0.0
Kansas City	963	161	181	29.01	30.04	+.02	66.7	−2.2	92	8	77	43	26	57	29	57	50	61	3.12	−1.4	8	5,680	s.	25	n.	2	18	8	4	3.4	0.0	0.0
St. Joseph	967	11	49	29.00	30.03		65.2		92	8	77	37	26	54	33	56	50	66	8.78		7	4,631	se.	27	nw.	11	21	6	3	2.7	0.0	0.0
Springfield, Mo.	1,324	98	104	28.68	30.08	+.05	66.3	−2.6	88	13	76	43	24	56	29	57	51	63	0.05	−3.7	2	5,738	s.	22	s.	12	25	4	1	1.7	0.0	0.0
Iola	984	11	50	29.01	30.04	+.03	68.0	−1.8	94	13	82	41	26	54	39				1.06	−2.8	4	3,171	s.	15	n.	21	19	10	1	3.2	0.0	0.0
Topeka	987	92	107				66.8	−0.9	95	8	79	38	26	55	35				2.51	−1.0	9	5,647	s.	20	se.	7	18	9	3	2.9	0.0	0.0
Lincoln	1,189	11	81	28.75	30.00	+.01	64.6	−1.8	95	8	78	34	26	52	40	54	46	59	2.01	−0.6	6	5,829	s.	36	nw.	11	18	4	8	3.6	0.0	0.0
Omaha	1,105	115	122	28.84	30.02	+.02	63.8	−3.0	89	15	75	36	25	53	35	54	48	62	2.73	−0.5	6	4,634	s.	33	nw.	11	20	9	1	2.5	0.0	0.0
Valentine	2,598	47	54	27.32	30.02	+.06	59.8	−2.7	91	7	74	24	27	46	53	48	39	55	0.78	−1.0	7	5,343	w.	31	n.	16	15	9	6	3.9	0.0	0.0
Sioux City	1,135	94	164	28.81	30.02	+.04	61.6	−1.8	91	9	73	31	25	50	35	52	46	62	2.14	−0.3	6	7,287	s.	36	w.	11	17	11	2	3.3	0.0	0.0
Huron	1,306	59	74	28.61	30.01	+.05	59.2	−2.1	91	7	72	27	25	46	42	48	40	60	1.30	−0.3	5	5,615	nw.	28	n.	16	15	10	5	3.6	0.0	0.0
Pierre	1,572	70	75		30.00	+.05	60.6	−3.2	92	7	74	26	27	47	47			58	0.41	−0.7	5	5,373	nw.	52	n.	15	14	9	7		0.0	0.0
Yankton	1,233	49	57	28.68	29.99	+.01	62.0	−2.0	91	8	74	30	25	49	43				1.42	−1.3	8	4,424	nw.	25	n.	16	14	13	3	3.6	0.0	0.0

TABLE 1.—*Climatological data for weather bureau stations, September, 1928*—Continued.

District and station	Elevation of instruments: Barometer above sea level	Elevation of instruments: Thermometer above ground	Elevation of instruments: Anemometer above ground	Pressure: Station reduced to mean of 24 hours	Pressure: Sea level, reduced to mean of 24 hours	Pressure: Departure from normal	Temperature of the air: Mean max. + mean min. ÷ 2	Temperature of the air: Departure from normal	Temperature of the air: Maximum	Temperature of the air: Date	Temperature of the air: Mean maximum	Temperature of the air: Minimum	Temperature of the air: Date	Temperature of the air: Mean minimum	Temperature of the air: Greatest daily range	Mean wet thermometer	Mean temperature of the dew-point	Mean relative humidity	Precipitation: Total	Precipitation: Departure from normal	Precipitation: Days with .01, or more	Wind: Total movement	Wind: Prevailing direction	Wind: Maximum velocity: Miles per hour	Wind: Maximum velocity: Direction	Wind: Maximum velocity: Date	Clear days	Partly cloudy days	Cloudy days	Average cloudiness, tenths	Total snowfall	Snow, sleet, and ice on ground at end of month
	Ft.	Ft.	Ft.	In.	In.	In.	°F.	°F.	°F.		°F.	°F.		°F.	°F.	°F.	°F.	%	In.	In.		Miles.								0-10	In.	In.
Northern Slope							56.9	−0.4										53	0.41	−0.8										3.8		
Billings	3,140	5	-----	-----	-----	-----	57.7	-----	95	6	76	27	21	39	54	-----	-----	-----	0.39	-----	3		nw.	-----	-----	-----	14	7	9	-----	0.0	0.0
Havre	2,505	11	44	27.39	30.02	+0.08	55.8	−0.6	88	18	71	18	27	41	51	45	37	57	0.42	−0.9	3	3,878	sw.	30	w.	29	17	6	7	4.1	0.0	0.0
Helena	4,110	87	112	25.85	30.01	+.04	56.2	−0.4	84	3	69	35	27	42	38	46	39	57	0.05	−1.0	4	5,196	sw.	25	sw.	14	12	14	4	4.4	0.0	0.0
Kalispell	2,973	48	56	26.94	29.98	+.02	55.2	+1.7	83	3	69	32	21	41	38	45	35	53	0.04	−1.3	2	3,738	nw.	23	ne.	7	20	7	3	2.7	0.0	0.0
Miles City	2,371	48	55	27.50	30.05	+.10	58.4	−2.8	93	6	73	24	27	44	46	46	35	50	0.34	−0.6	5	3,082	s.	21	n.	7	16	9	5	3.5	0.0	0.0
Rapid City	3,259	50	58	26.65	30.04	+.08	59.0	−1.4	95	6	72	29	27	46	47	48	38	51	1.72	+0.5	3	4,932	n.	35	nw.	13	16	7	7	3.9	T.	0.0
Cheyenne	6,088	84	101	24.10	29.90	+.03	57.2	+0.2	85	6	70	31	25	44	39	43	31	42	0.08	−1.1	4	7,146	w.	44	w.	11	15	12	3	3.6	0.0	0.0
Lander	5,372	60	68	24.72	30.02	+.06	57.0	+1.3	87	6	74	29	21	40	45	44	34	49	0.02	−1.0	1	3,157	w.	35	nw.	30	15	11	4	3.9	0.0	0.0
Sheridan	3,790	10	47	26.14	30.03	-----	55.4	-----	92	6	73	26	27	38	50	44	36	60	0.29	-----	7	2,659	nw	22	nw.	7	17	8	5	3.5	0.0	0.0
Yellowstone Park	6,241	11	48	23.97	30.04	+.07	51.4	−2.0	80	17	67	28	21	36	43	40	30	52	0.03	−1.0	1	4,771	sw.	36	sw.	6	10	11	9	5.0	T.	0.0
North Platte	2,821	11	51	27.10	30.01	+.04	62.4	+0.3	98	8	77	30	27	47	48	50	42	59	0.96	−0.4	7	3,635	se.	24	n.	20	20	5	5	3.1	0.0	0.0
Middle Slope							67.6	−0.4										52	0.56	−1.4										2.7		
Denver	5,292	106	113	24.80	30.00	+.04	62.6	−0.3	90	7	76	36	27	49	37	47	35	42	0.07	−0.9	2	4,475	s.	41	nw.	13	16	11	3	3.2	0.0	0.0
Pueblo	4,685	80	86	25.35	29.98	+.02	64.6	0.0	92	7	81	38	27	48	48	48	35	42	0.12	−0.5	2	4,143	nw.	40	nw.	13	22	7	1	2.3	0.0	0.0
Concordia	1,392	50	58	28.57	30.03	+.04	67.2	−1.1	96	13	80	39	25	54	38	54	46	56	0.85	−1.8	7	4,687	s.	26	nw.	20	13	11	6	4.0	0.0	0.0
Dodge City	2,509	11	51	27.45	30.02	+.04	68.5	−0.9	97	7	83	42	26	54	40	54	45	55	1.13	−0.8	4	5,749	se.	22	s.	19	26	3	1	1.1	0.0	0.0
Wichita	1,358	139	158	28.59	30.00	.00	70.4	−0.2	98	12	83	48	26	57	42	58	50	55	0.58	−2.6	4	8,462	s.	34	s.	9	21	8	1	2.5	0.0	0.0
Broken Arrow	765	11	56	29.23	30.06	-----	69.2	-----	91	12	81	44	24	57	34	-----	-----	-----	1.29	-----	4	6,779	s.	28	s.	10	20	7	3	2.6	0.0	0.0
Oklahoma City	1,214	10	47	28.75	30.01	+.02	72.6	−0.2	95	12	84	51	26	61	35	60	53	50	0.61	−2.1	4	5,692	s.	20	s.	11	19	8	3	2.9	0.0	0.0
Southern Slope							72.8	−0.7										62	2.34	0.6										3.4		
Abilene	1,738	10	52	28.22	30.00	+.04	74.8	−0.5	96	12	86	49	24	64	37	62	56	63	0.54	−2.2	2	4,729	s.	23	s.	13	16	7	7	4.1	0.0	0.0
Amarillo	3,676	10	49	26.34	30.01	+.05	70.4	+1.1	94	30	84	48	21	57	37	56	48	54	1.31	−1.0	5	5,430	s.	25	n.	4	24	3	3	1.8	0.0	0.0
Del Rio	944	64	71	28.97	29.94	.00	77.4	−1.8	96	2	86	59	22	69	26	68	64	71	7.06	+4.6	10	4,036	se.	22	se.	10	12	8	10	5.2	0.0	0.0
Roswell	3,566	75	85	26.42	29.98	+.06	68.8	−1.5	96	12	82	45	24	55	42	56	48	58	0.43	−1.4	5	4,002	s.	32	n.	20	21	5	4	2.6	0.0	0.0
Southern Plateau							72.9	+2.2										44	0.12	−0.7										1.5		
El Paso	3,778	152	175	26.22	29.92	+.04	74.4	+0.5	95	12	86	54	23	63	30	58	48	47	0.04	−1.2	3	5,517	e.	30	ne.	21	21	5	4	2.8	0.0	0.0
Santa Fe	7,013	38	53	23.37	29.94	+.01	61.5	+0.6	82	16	75	38	22	48	35	46	35	45	0.13	−1.3	2	3,333	e.	18	ne.	9	24	5	1	1.8	0.0	0.0
Flagstaff	6,907	10	50	23.45	29.91	+.02	59.7	+4.2	84	16	77	33	13	43	46	45	-----	51	0.17	-----	4	-----	nw.	-----	sw.	5	18	11	1	-----	0.0	0.0
Phoenix	1,108	10	82	28.66	29.78	−.03	85.2	+2.5	109	16	100	61	13	70	42	64	50	34	0.44	−0.6	1	2,531	e.	15	se.	17	28	1	1	1.2	0.0	0.0
Yuma	141	9	54	29.62	29.76	−.02	86.4	+2.7	112	17	103	60	11	70	46	67	55	43	T.	−0.4	0	2,679	sw.	23	ne.	22	29	1	0	0.3	0.0	0.0
Independence	3,957	6	27	25.92	29.90	+.04	70.4	+2.4	95	2	87	44	28	53	41	49	-----	-----	0.00	−0.1	0	-----	nw.	-----	-----	-----	23	7	0	-----	0.0	0.0
Middle Plateau							64.4	+2.5										32	0.21	−0.5										2.1		
Reno	4,532	74	81	25.48	29.92	−.03	63.4	+3.7	94	2	81	33	13	46	47	46	31	36	T.	−0.3	0	4,147	w.	27	w.	12	23	6	1	2.0	0.0	0.0
Tonopah	6,000	12	20	-----	-----	-----	66.4	-----	86	3	77	39	13	56	31	45	19	17	0.00	-----	0	-----	se.	-----	-----	-----	-----	-----	-----	-----	-----	-----
Winnemucca	4,344	18	56	25.64	29.98	+.05	60.3	+1.1	95	3	81	26	13	40	53	45	33	43	0.10	−0.3	1	3,962	sw.	29	sw.	12	21	9	0	2.4	0.0	0.0
Modena	5,473	10	43	24.65	29.90	−.02	62.3	+2.3	89	3	81	31	13	43	49	44	26	31	0.19	−0.9	2	6,779	sw.	42	nw.	4	25	5	0	1.5	0.0	0.0
Salt Lake City	4,360	163	203	25.63	29.94	−.01	67.2	+2.8	92	5	80	41	13	54	35	40	31	29	0.16	−0.8	2	4,686	s.	34	se.	26	18	10	2	2.7	0.0	0.0
Grand Junction	4,602	60	68	25.41	29.94	−.01	68.6	+2.4	90	5	83	45	14	54	36	50	34	35	0.61	−0.3	4	3,847	se.	30	w.	8	24	4	2	2.1	0.0	0.0
Northern Plateau							62.7	+2.1										42	0.38	−0.4										3.3		
Baker	3,471	48	53	26.47	30.03	+.04	58.0	+2.0	93	3	75	30	20	41	45	46	33	46	0.60	−0.2	3	3,642	se.	22	sw.	11	19	6	5	3.1	0.0	0.0
Boise	2,739	78	86	27.16	29.98	+.01	64.3	+2.4	93	3	80	38	20	49	39	50	37	43	0.25	−0.3	2	2,607	se.	22	w.	8	17	12	1	2.9	0.0	0.0
Lewiston	757	40	48	29.17	29.97	−.01	64.6	+1.8	100	2	81	38	20	48	47	-----	-----	-----	0.26	−0.4	2	1,767	e.	21	nw.	18	17	6	7	3.5	0.0	0.0
Pocatello	4,477	60	68	25.49	29.94	−.02	62.4	+2.2	89	3	78	34	21	46	44	46	30	34	0.22	−0.7	5	4,615	se.	36	sw.	12	10	13	7	4.7	T.	0.0
Spokane	1,929	101	110	27.95	29.98	.00	61.6	+2.4	95	2	77	35	20	47	45	48	34	43	0.07	−0.8	3	2,879	s.	24	sw.	18	22	4	4	2.7	0.0	0.0
Walla Walla	991	57	65	28.91	29.97	−.03	65.4	+1.6	98	2	78	43	20	53	33	52	40	44	0.86	−0.1	3	2,483	s.	18	w.	18	20	7	3	2.7	0.0	0.0
North Pacific Coast Region							58.0	−0.2										73	1.19	−1.3										4.9		
North Head	211	11	56	29.79	30.01	−.02	55.6	−0.9	87	22	60	48	20	52	35	53	52	89	2.13	−0.4	12	7,345	n.	54	s.	12	9	6	15	6.1	0.0	0.0
Port Angeles	29	8	53	-----	30.03	-----	54.2	-----	71	2	62	39	10	46	26	-----	-----	-----	0.52	−1.3	5	3,311	sw.	27	w.	18	15	6	9	-----	0.0	0.0
Seattle	125	215	250	29.90	30.08	+.07	58.4	+0.3	82	1	65	45	8	52	26	53	49	72	0.53	−1.2	4	4,114	n.	26	s.	13	12	4	14	5.3	0.0	0.0
Tacoma	104	172	201	29.84	30.04	+.02	58.2	+0.9	80	22	66	42	20	50	29	-----	-----	-----	0.48	−1.6	5	4,236	n.	28	sw.	18	8	12	10	5.8	0.0	0.0
Tatoosh Island	86	9	53	29.94	30.04	+.03	52.6	−0.4	75	22	56	46	2	49	23	51	50	92	3.20	−2.9	10	7,782	s.	55	s.	13	8	3	19	6.8	0.0	0.0
Yakima	1,071	5	-----	-----	-----	-----	63.1	-----	98	2	81	34	21	45	54	52	-----	63	0.38	-----	3	-----	nw.	-----	-----	-----	19	9	2	2.9	0.0	0.0
Medford	1,425	4	80	28.47	29.96	-----	63.6	-----	99	21	82	37	8	46	53	52	43	60	1.23	-----	4	-----	nw.	19	se.	16	21	5	4	2.4	0.0	0.0
Portland, Oreg	153	68	106	29.87	30.03	.00	61.5	−0.2	90	22	70	43	19	53	31	55	50	68	0.65	−1.3	5	3,341	nw.	16	e.	21	10	8	12	5.6	0.0	0.0
Roseburg	510	75	99	29.47	30.01	−.01	61.8	−1.1	91	21	74	39	9	49	48	53	47	64	0.84	−0.4	4	2,295	n.	17	n.	19	14	10	6	4.2	0.0	0.0
Middle Pacific Coast Region							65.2	+0.4										65	0.12	−0.5										3.6		
Eureka	62	73	89	29.96	30.03	+.02	55.2	−0.7	82	21	60	45	11	50	28	52	51	88	0.58	−0.4	3	2,953	n.	25	n.	19	4	10	16	6.7	0.0	0.0
Red Bluff	330	54	58	29.54	29.88	−.05	73.4	+0.3	104	21	91	47	27	56	47	57	44	41	T.	−0.8	0	3,071	nw.	19	w.	7	25	4	1	2.0	0.0	0.0
Sacramento	69	106	117	29.81	29.88	−.01	71.4	+2.1	102	21	87	49	9	56	45	58	48	53	T.	−0.4	0	4,549	s.	20	sw.	11	23	7	0	1.4	0.0	0.0
San Francisco	155	208	243	29.77	29.94	.00	61.2	+0.3	99	21	69	50	3	54	35	54	51	77	0.03	−0.4	2	4,519	w.	30	w.	8	11	10	9	4.7	0.0	0.0
San Jose	141	12	110	29.79	29.94	-----	64.8	+0.1	101	21	79	43	9	51	47	-----	-----	-----	0.00	−0.4	0	3,221	nw.	20	nw.	12	16	13	1	3.0	0.0	0.0
South Pacific Coast Region							70.9	+1.1										61	T.	−0.2										1.6		
Fresno	327	89	98	29.53	29.87	.00	75.6	+2.2	104	22	92	49	11	50	40	57	40	35	0.00	−0.2	0	4,294	nw.	21	nw.	29	27	3	0	1.0	0.0	0.0
Los Angeles	338	150	191	29.52	29.88	.00	71.0	+2.0	95	6	82	56	22	60	31	60	55	67	0.00	−0.2	0	2,817	sw.	15	sw.	8	25	5	0	1.6	0.0	0.0
San Diego	87	62	70	29.78	29.87	−.02	66.2	−0.9	80	7	72	58	21	60	17	62	59	82	T.	−0.1	0	3,912	nw.	18	nw.	1	24	4	2	2.2	0.0	0.0
West Indies																																
San Juan, P. R	82	9	54	29.84	29.92	-----	80.2	−0.3	90	15	85	70	13	75	16	-----	-----	-----	13.68	+6.9	18	8,607	e.	[1]165	ne.	13	1	25	4	5.9	0.0	0.0
Panama Canal																																
Balboa Heights	118	7	97	[2]29.75	[2]29.83	−.01	79.8	0.0	90	28	85	72	22	75	17	-----	-----	-----	10.44	+2.5	23	-----	nw.	-----	se.	22	0	9	21	8.1	0.0	0.0
Colon	38	7	97	[2]29.82	[2]29.83	−.01	81.8	+1.4	92	5	88	73	22	70	17	-----	-----	-----	15.46	+3.0	23	-----	se.	-----	n.	7	0	5	25	8.4	0.0	0.0
Alaska																																
Juneau	80	11	50	[3]29.85	[3]29.94	-----	49.4	-----	66	23	54	41	6	45	22	48	46	89	8.44	-----	24	4,058	se.	25	e.	9	2	3	25	8.8	0.0	0.0
Hawaiian Islands																																
Honolulu	38	86	100	[3]29.97	[3]30.01	-----	77.9	-----	84	26	82	70	22	73	13	70	66	69	0.51	−0.8	9	6,534	e.	24	e.	5	6	24	0	4.3	0.0	0.0

[1] Estimated; anemometer destroyed before velocity which seemed greatest. [2] Observations taken bi-hourly. [3] Pressure not reduced to mean of 24 hours.

TABLE 2.—*Data furnished by the Canadian Meteorological Service, September, 1928*

Station	Altitude above mean sea level, Jan. 1, 1919	Pressure: Station reduced to mean of 24 hours	Pressure: Sea level reduced to mean of 24 hours	Pressure: Departure from normal	Temperature of the air: Mean max. + mean min. ÷ 2	Temperature of the air: Departure from normal	Temperature of the air: Mean maximum	Temperature of the air: Mean minimum	Temperature of the air: Highest	Temperature of the air: Lowest	Precipitation: Total	Precipitation: Departure from normal	Precipitation: Total snowfall
	Feet	Inches	Inches	Inch	°F.	°F.	°F.	°F.	°F.	°F.	Inches	Inches	Inch
Cape Race, N. F	99				53.6		61.3	45.8	70	38	4.24		0.0
Sydney, C. B. I	48	29.99	30.04	+0.03	57.3	+0.8	66.2	48.5	78	37	4.30	+1.02	0.0
Halifax, N. S	88	29.95	30.05	+.01	57.7	+0.1	66.5	49.0	80	34	2.40	−1.31	0.0
Yarmouth, N. S	65	29.91	29.98	−.07	56.7	+0.6	63.8	49.6	76	38	4.21	+0.60	0.0
Charlottetown, P. E. I	38	29.92	29.96	−.05	57.5	+0.2	64.0	51.0	75	41	3.96	+0.56	0.0
Chatham, N. B	28	29.91	29.94	−.06	52.8	−2.6	63.5	42.2	76	29	2.66	−0.05	0.0
Father Point, Que	20												
Quebec, Que	296	29.71	30.03	+.02	53.2	−1.9	59.8	46.6	72	34	2.77	−0.90	0.0
Doucet, Que	1,236				45.6		55.0	36.3	72	22	4.76		0.0
Montreal, Que	187	29.79	29.99	−.05	55.9	−2.5	63.1	48.7	80	36	4.47	+1.17	0.0
Ottawa, Ont	236	29.74	30.00	−.04	55.7	−1.7	64.9	46.6	80	33	4.17	+1.48	0.0
Kingston, Ont	285	29.70	30.01	−.03	57.4	−2.6	64.4	50.5	75	35	1.59	−1.21	0.0
Toronto, Ont	379	29.60	30.00	−.06	57.7	−1.3	66.6	48.8	80	33	2.85	−0.40	0.0
Cochrane, Ont	930				47.7		56.9	38.5	74	27	4.53		0.0
White River, Ont	1,244	28.60	29.92	−.06	46.4	−3.9	56.9	35.9	74	27	3.65	+0.88	5.0
London, Ont	808				57.4		68.2	46.7	87	31	2.92		0.2
Southampton, Ont	656	29.29	30.00	−.05	55.7	−1.8	64.9	46.5	81	34	3.74	+0.80	T.
Parry Sound, Ont	688	29.29	29.99	−.04	53.4	−2.6	61.3	45.6	73	30	7.26	+3.59	0.8
Port Arthur, Ont	644	29.26	29.97	−.01	50.9	−1.3	58.6	43.2	75	29	4.14	+0.66	0.0
Winnipeg, Man	760												
Minnedosa, Man	1,690	28.15	29.96	+.02	49.9	−0.6	62.3	37.6	83	22	0.19	−1.17	0.0
Le Pas, Man	860				48.6		60.6	36.7	79	29	0.44		0.0
Qu'Appelle, Sask	2,115	27.74	29.98	+.06	51.7	+0.6	66.0	37.4	88	16	0.40	−0.93	0.0
Moose Jaw, Sask	1,759				52.7		68.7	36.8	90	13	0.44		0.0
Swift Current, Sask	2,392	27.44	29.95	+.03	54.6	+1.5	71.9	37.3	88	11	0.14	−1.08	0.0
Medicine Hat, Alb	2,144	27.69	29.94	+.02	55.4	+0.4	71.3	39.6	90	18	0.02	−1.16	0.0
Calgary, Alb	3,428	26.45	30.01	+.09	52.8	+3.0	70.0	35.6	87	18	0.04	−1.32	0.0
Banff, Alb	4,521	25.43	29.98	+.05	50.0	+4.2	65.8	34.2	82	20	0.27	−1.40	0.0
Prince Albert, Sask	1,450	28.41	29.98	+.08	49.6	+1.2	63.7	35.6	84	18	0.20	−1.08	0.0
Battleford, Sask	1,592	28.22	29.95	+.05	51.9	+0.1	68.0	35.8	88	15	0.47	−0.78	0.0
Edmonton, Alb	2,150	27.65	29.91	+.01	51.1	+1.8	66.4	35.9	83	14	0.71	−0.62	0.0
Kamloops, B. C	1,262												
Victoria, B. C	230	29.78	30.03	+.02	56.6	+1.8	63.4	49.8	82	46	0.45	−1.71	0.0
Barkerville, B. C	4,180												
Estevan Point, B. C	20												
Prince Rupert, B. C	170												
Hamilton, Ber	151	29.96	30.12	+.05	79.3	+1.9	86.7	72.0	92	69	7.70	+1.19	0.0

LATE REPORTS FOR JULY AND AUGUST, 1928

JULY

Station	Altitude	Station pressure	Sea level pressure	Departure	Mean	Departure	Mean max.	Mean min.	Highest	Lowest	Total	Departure	Total snowfall
Father Point, Que	20	29.84	29.86	+.01	58.6	+1.0	66.6	50.6	77	42	3.32	+0.28	0.0
Barkerville, B. C	4,180	25.71	29.97	+.06	56.2	+1.1	68.0	44.5	80	36	2.68	−0.34	0.0

AUGUST

Station	Altitude	Station pressure	Sea level pressure	Departure	Mean	Departure	Mean max.	Mean min.	Highest	Lowest	Total	Departure	Total snowfall
Sydney, C. B. I	48	29.99	30.04	+.09	65.1	+1.8	73.6	56.5	90	46	1.66	−1.96	0.0
Halifax, N. S	88	29.95	30.05	+.09	65.5	+1.9	73.6	57.5	94	42	0.85	−3.50	0.0
Yarmouth, N. S	65	29.92	29.99	+.02	64.4	+4.2	71.2	57.5	79	47	2.11	−1.51	0.0
Charlottetown, P. E. I	38	29.92	29.96	+.02	66.5	+2.2	73.0	60.0	88	53	3.09	−0.65	0.0
Chatham, N. B	28	29.91	29.94	+.01	63.5	+0.3	72.6	54.5	93	40	4.46	+0.42	0.0
Father Point, Que	20	29.96	29.98	+.07	57.2	+1.6	65.7	48.7	80	40	2.60	−0.45	0.0
Medicine Hat, Alb	2,144	27.66	29.88	+.06	64.2	−1.5	78.2	50.2	97	35	0.27	−1.40	0.0
Calgary, Alb	3,428	26.46	29.98	+.07	58.5	−0.9	72.3	44.8	90	32	1.90	−0.24	0.0
Banff, Alb	4,521	25.44	29.95	+.04	54.7	−1.6	68.5	41.0	87	29	2.05	−0.48	0.0
Edmonton, Alb	2,150	27.66	29.92	.00	57.1	−1.7	69.9	44.3	92	32	1.70	−0.43	0.0
Kamloops, B. C	1,262	28.69	29.95	+.04	67.3	−1.3	80.2	54.4	93	42	0.50	−0.59	0.0
Barkerville, B. C	4,180	25.73	30.02	+.12	51.2	−5.1	62.3	40.1	72	30	2.97	−0.13	0.0
Estevan Point, B. C	20				55.7		61.5	49.9	66	46	4.15		0.0
Prince Rupert, B. C	170				56.5		64.1	49.0	75	45	3.37		0.0

Chart I. Departure (°F.) of the Mean Temperature from the Normal, September, 1928

Chart I. Departure (°F.) of the Mean Temperature from the Normal, September, 1928

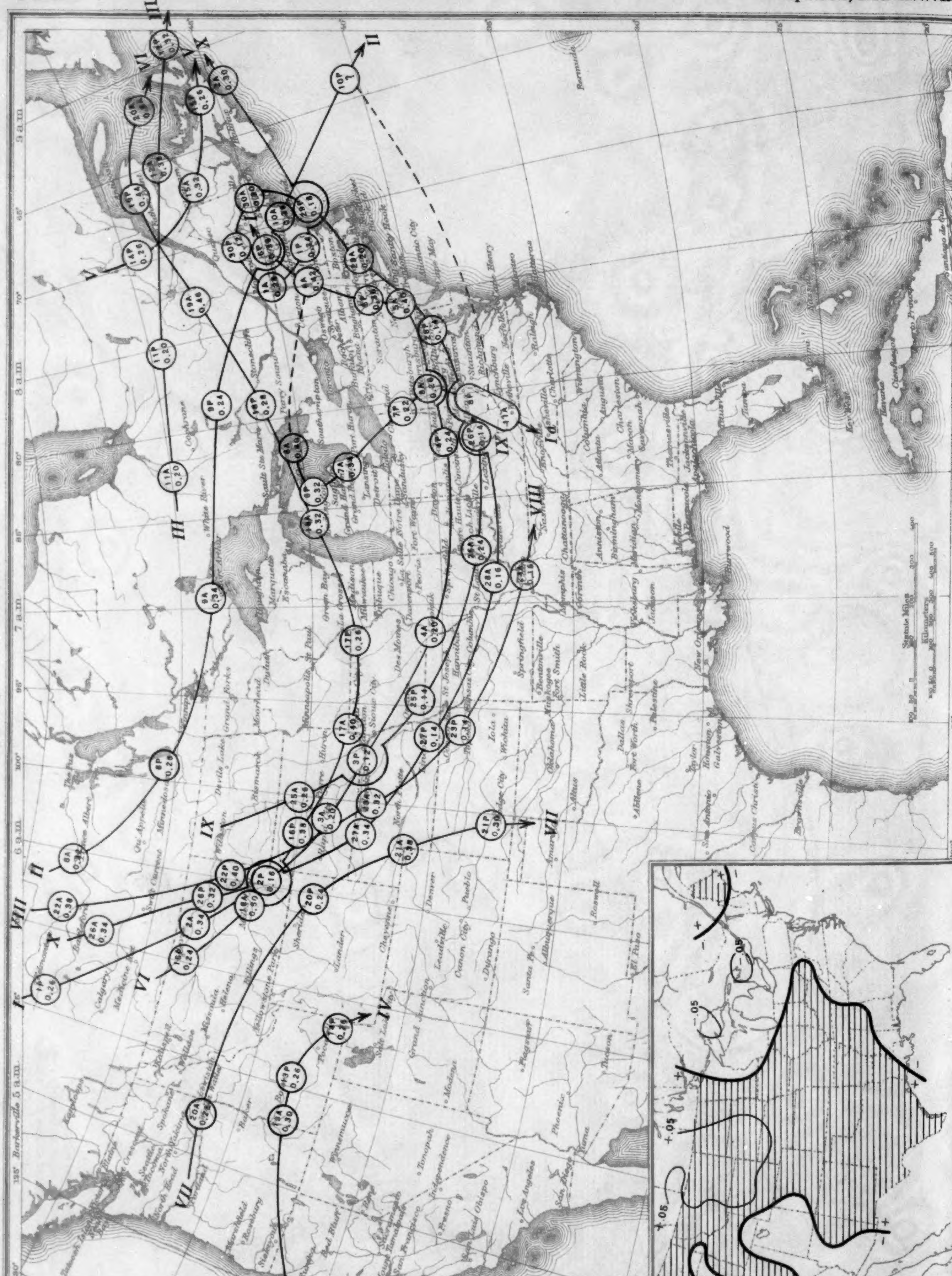
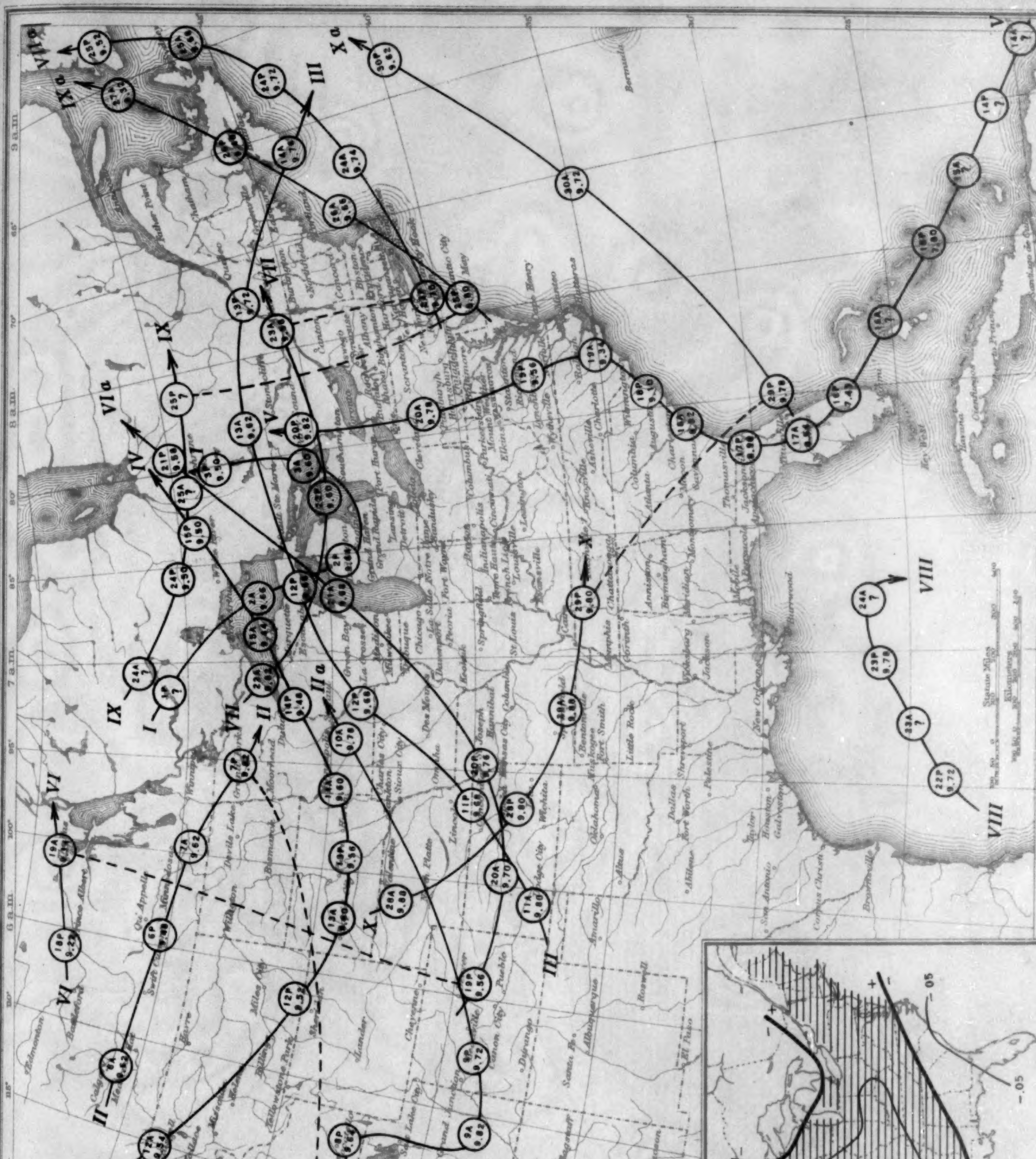


Chart II. Tracks of Centers of Anticyclones, September, 1928. (Inset) Departure of Monthly Mean Pressure from Normal

(Plotted by Wilfred P. Day)

(Plotted by Wilfred P. Day)



(Plotted by Wilfred P. Day)

Chart IV. Percentage of Clear Sky between Sunrise and Sunset, September, 1928

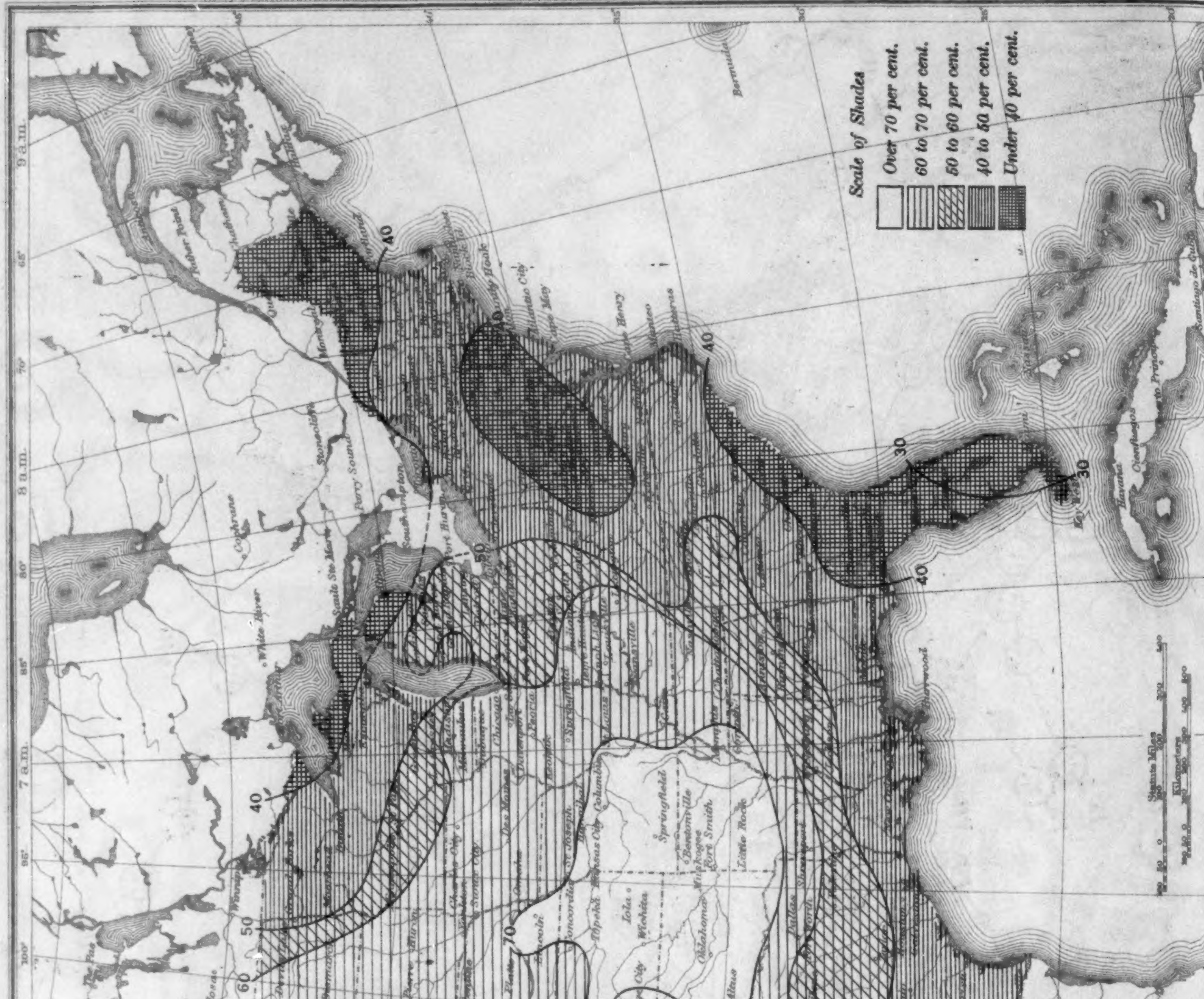


Chart V. Total Precipitation, Inches, September, 1928. (Inset) Departure of Precipitation from Normal

Chart VI. Isobars at Sea level and Isotherms at Surface; Prevailing Winds, September, 1928

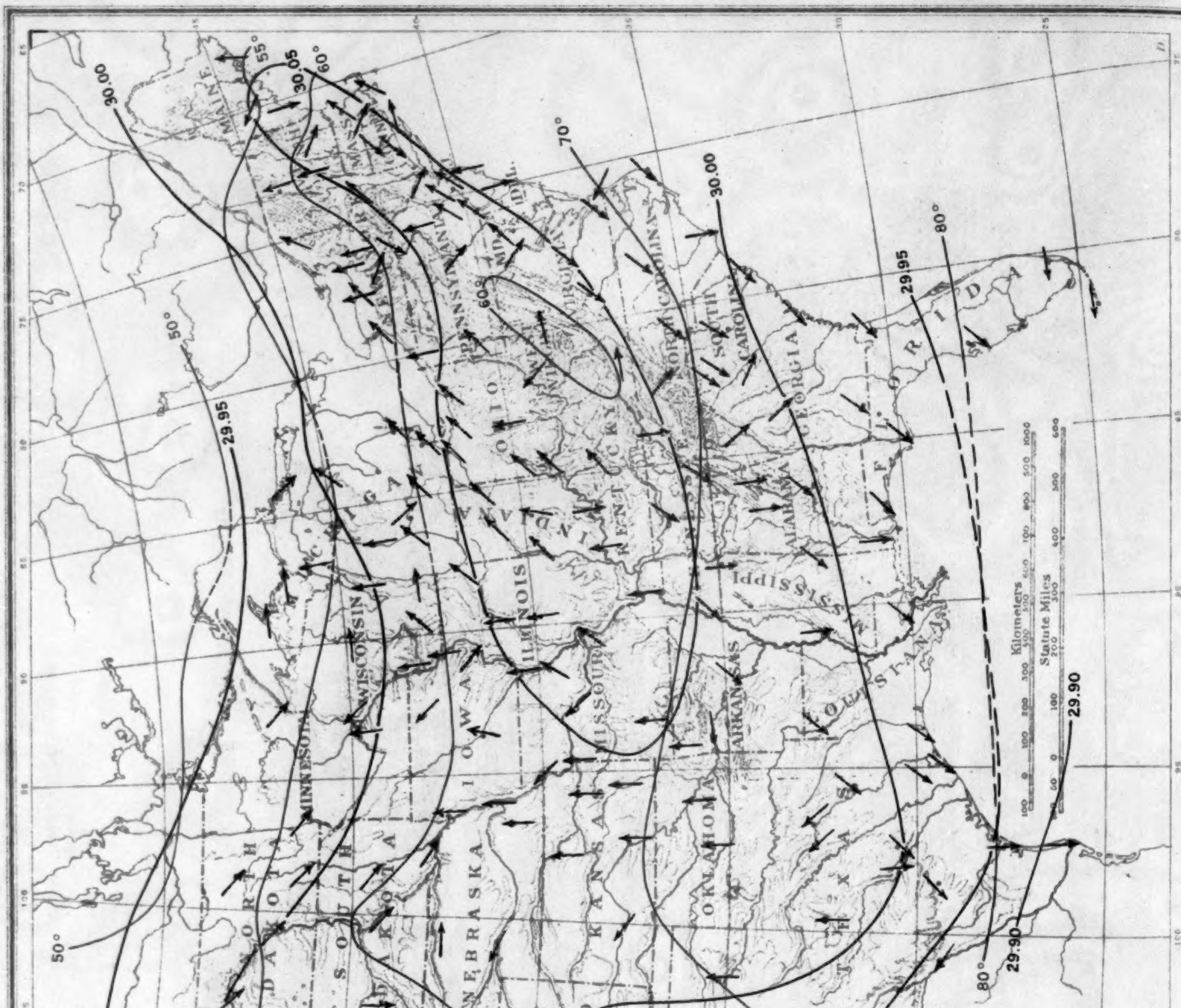
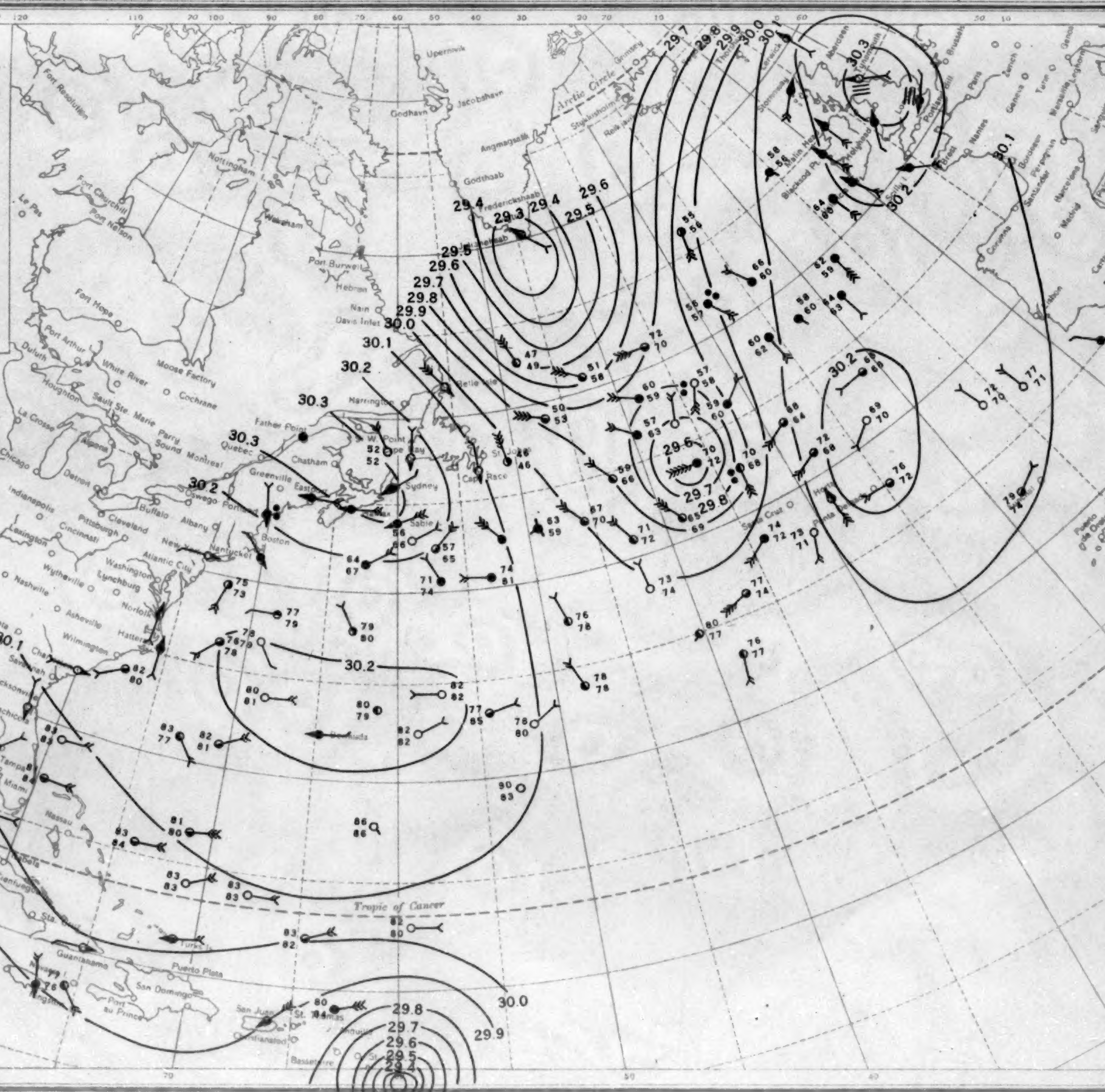


Chart VIII. Weather Map of North Atlantic Ocean, September 12, 1928

Chart VIII. Weather Map of North Atlantic Ocean, September 12, 1928
(Plotted by F. A. Young)



Greenwich Mean Noon.

Isobars show corrected barometric readings in inches of mercury.

Arrows fly with the wind.

Number of feathers indicate force, Beaufort scale.

Weather symbols are as follows:

○ clear, ◐ partly cloudy, ● cloudy, ⁝ rain, ▲ hail or sleet, ✳ snow, ≡ fog.

Pointed arrows indicate land stations.

Pairs of numbers indicate temperatures of air and surface of water in Fahrenheit degrees. Upper number, air; lower, water.

Chart IX. Weather Map of North Atlantic Ocean, September 13, 1928

(Plotted by F. A. Young)

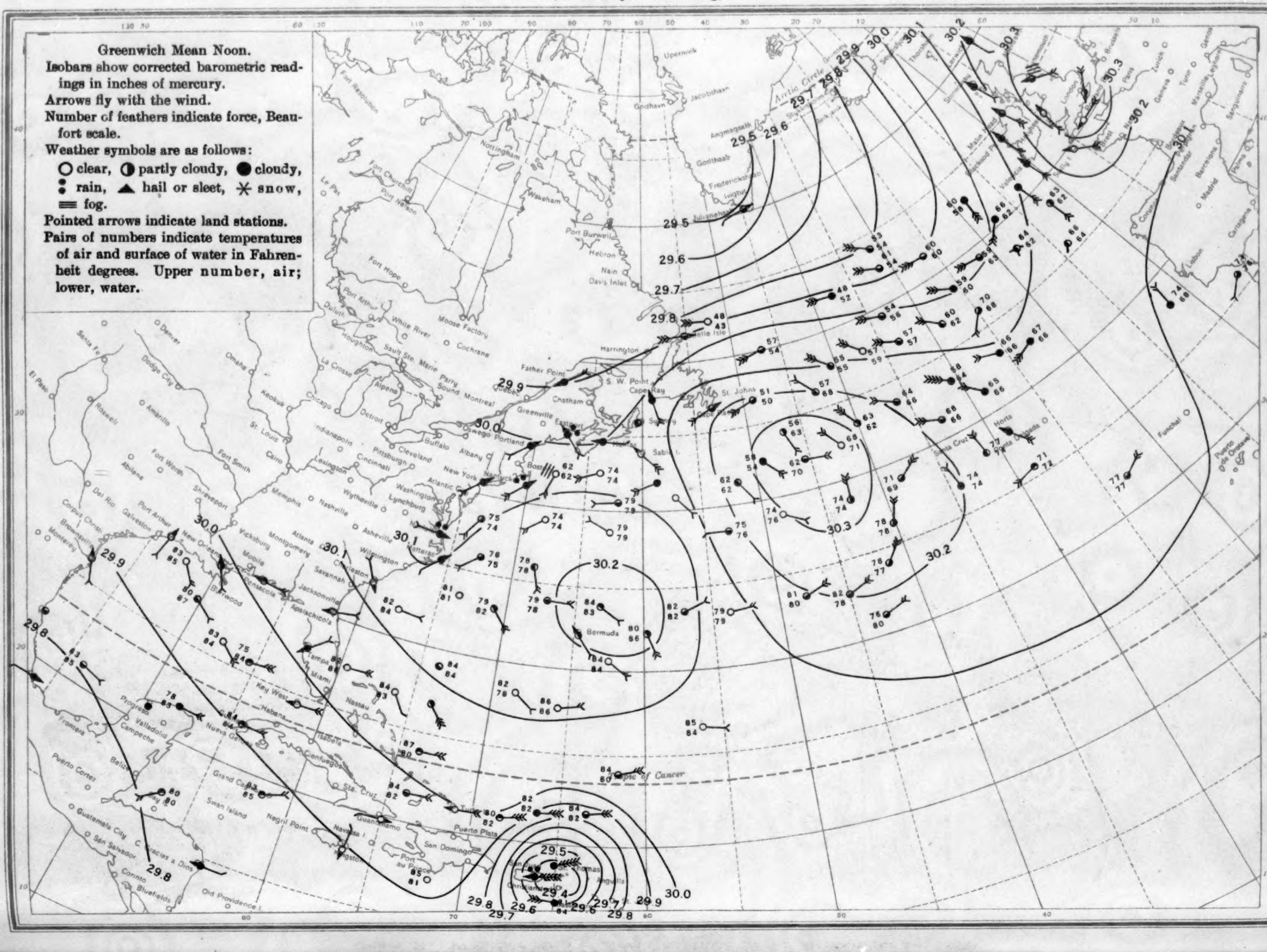


Chart X. Weather Map of North Atlantic Ocean, September 14, 1928

(Plotted by F. A. Young)

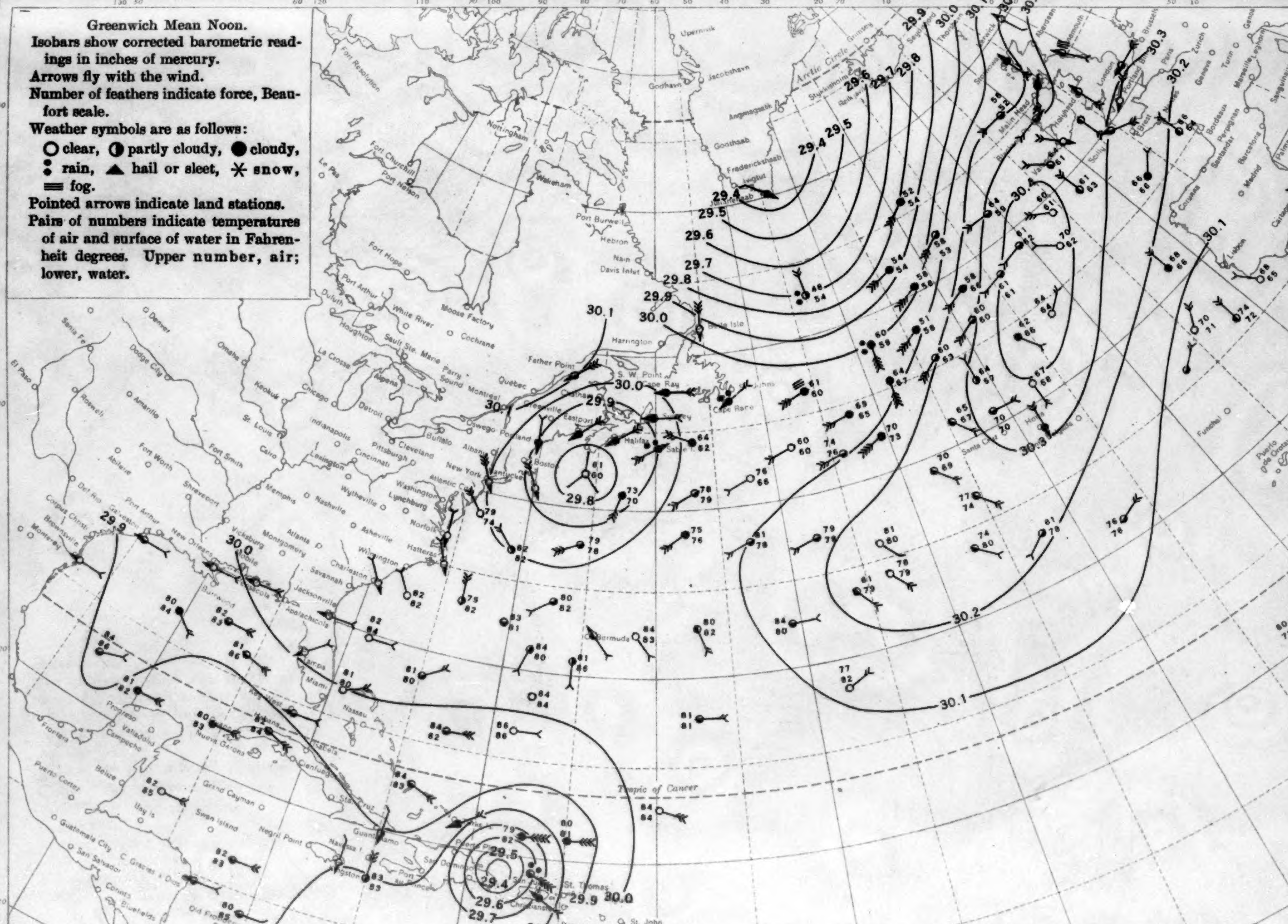


Chart XI. Weather Map of North Atlantic Ocean, September 15, 1928

(Plotted by F. A. Young)

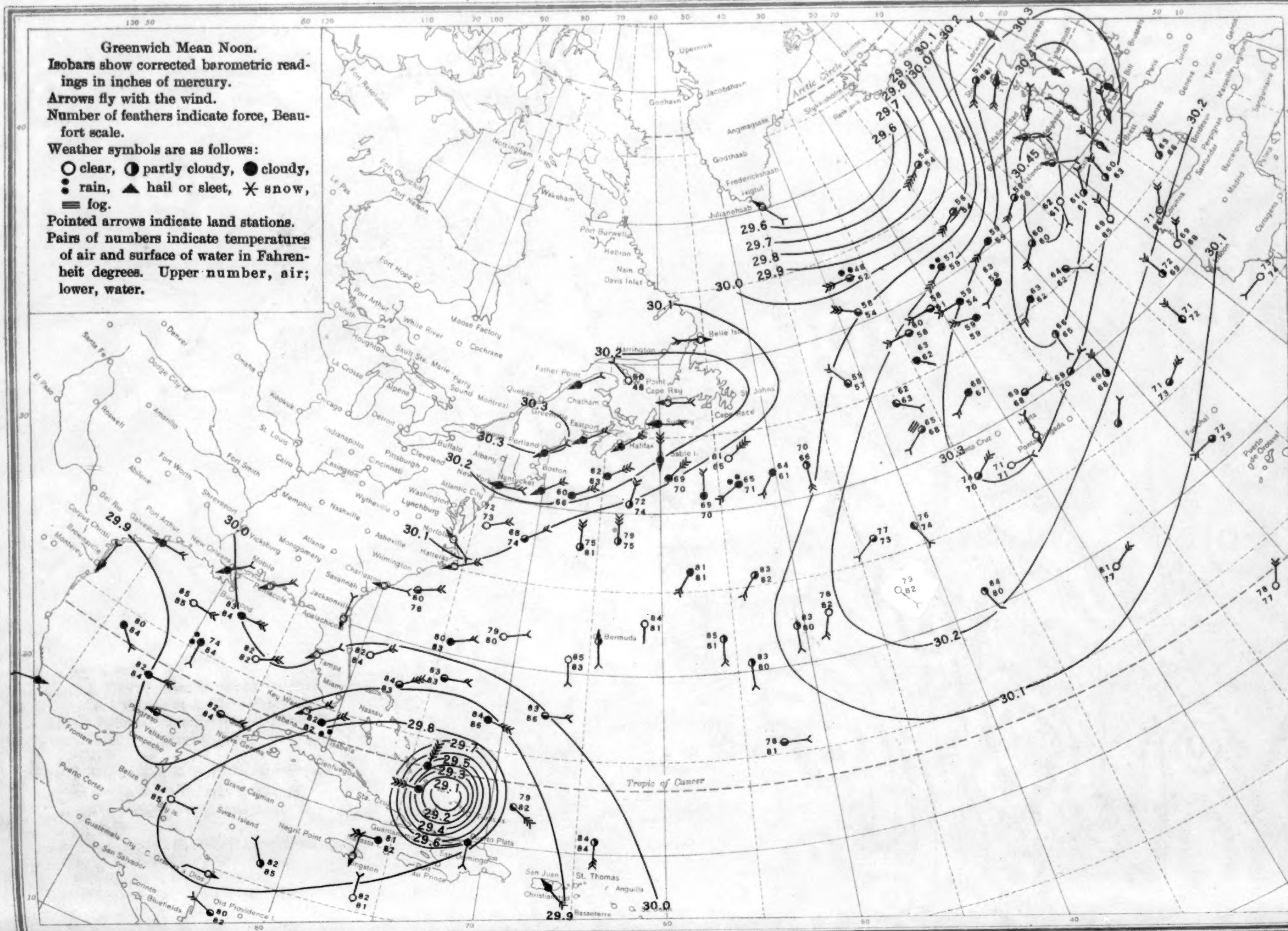


Chart XII. Weather Map of North Atlantic Ocean, September 16, 1928
(Plotted by F. A. Young)

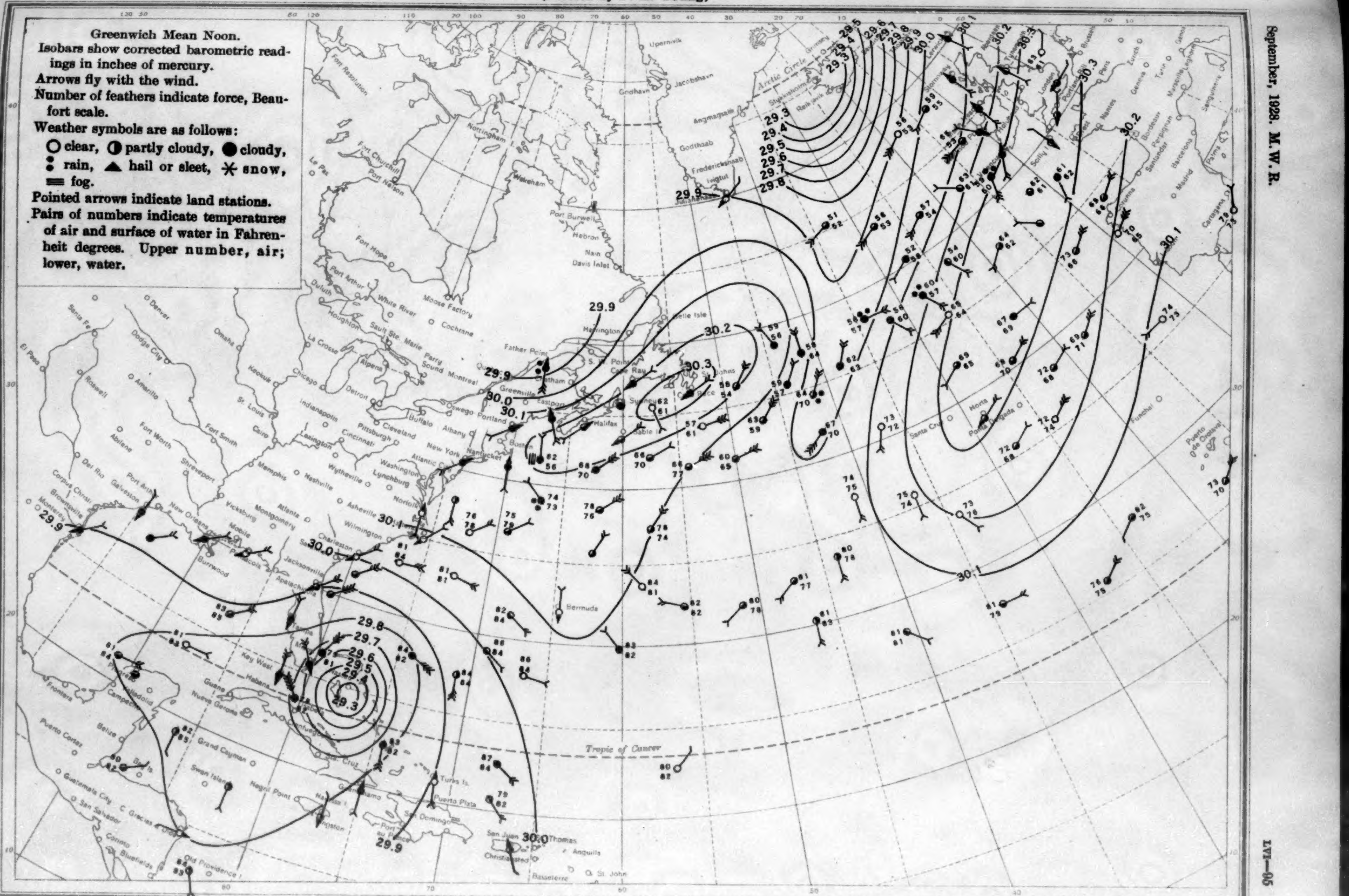


Chart XIII. Weather Map of North Atlantic Ocean, September 17, 1928

(Plotted by F. A. Young)

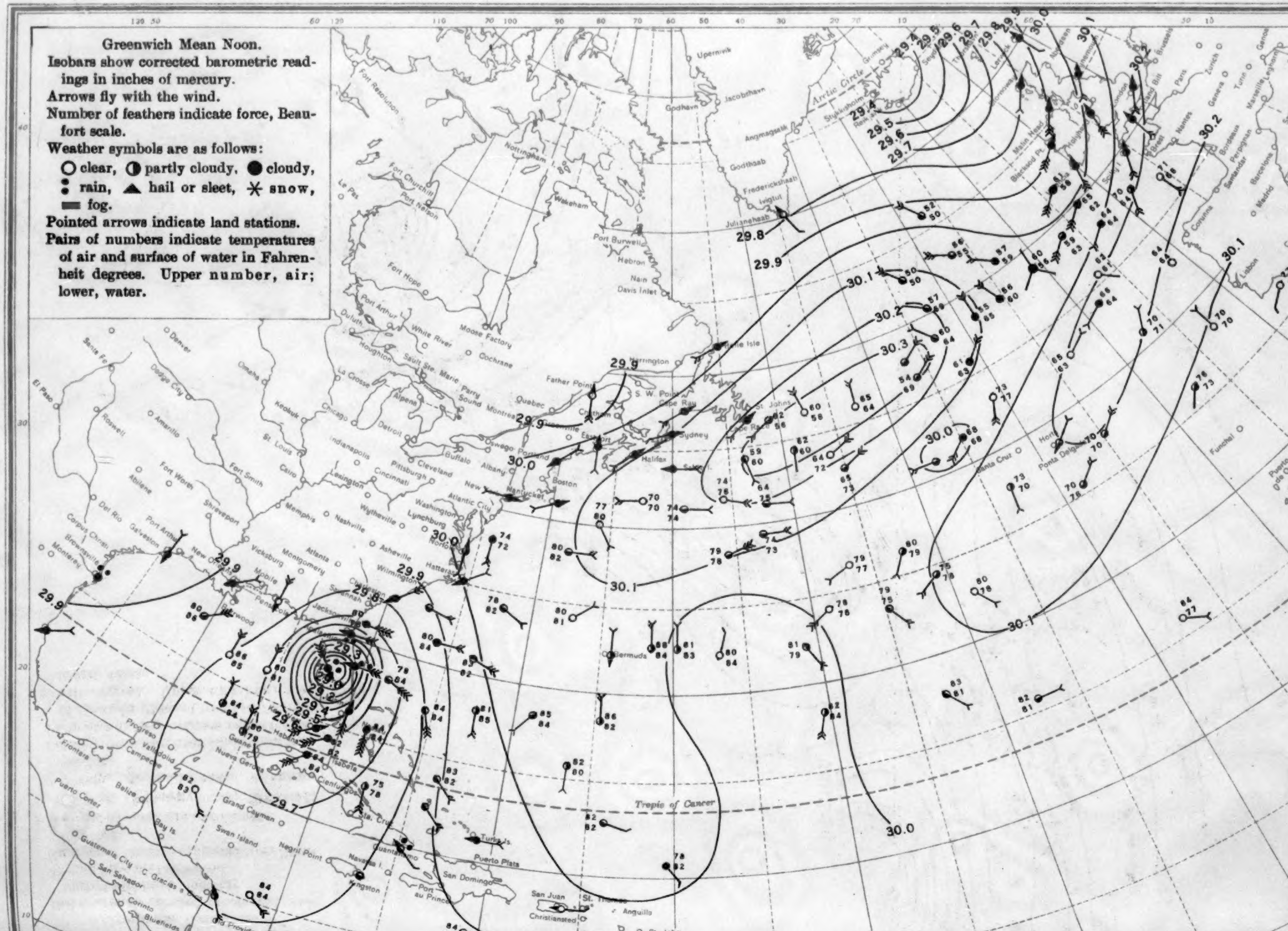
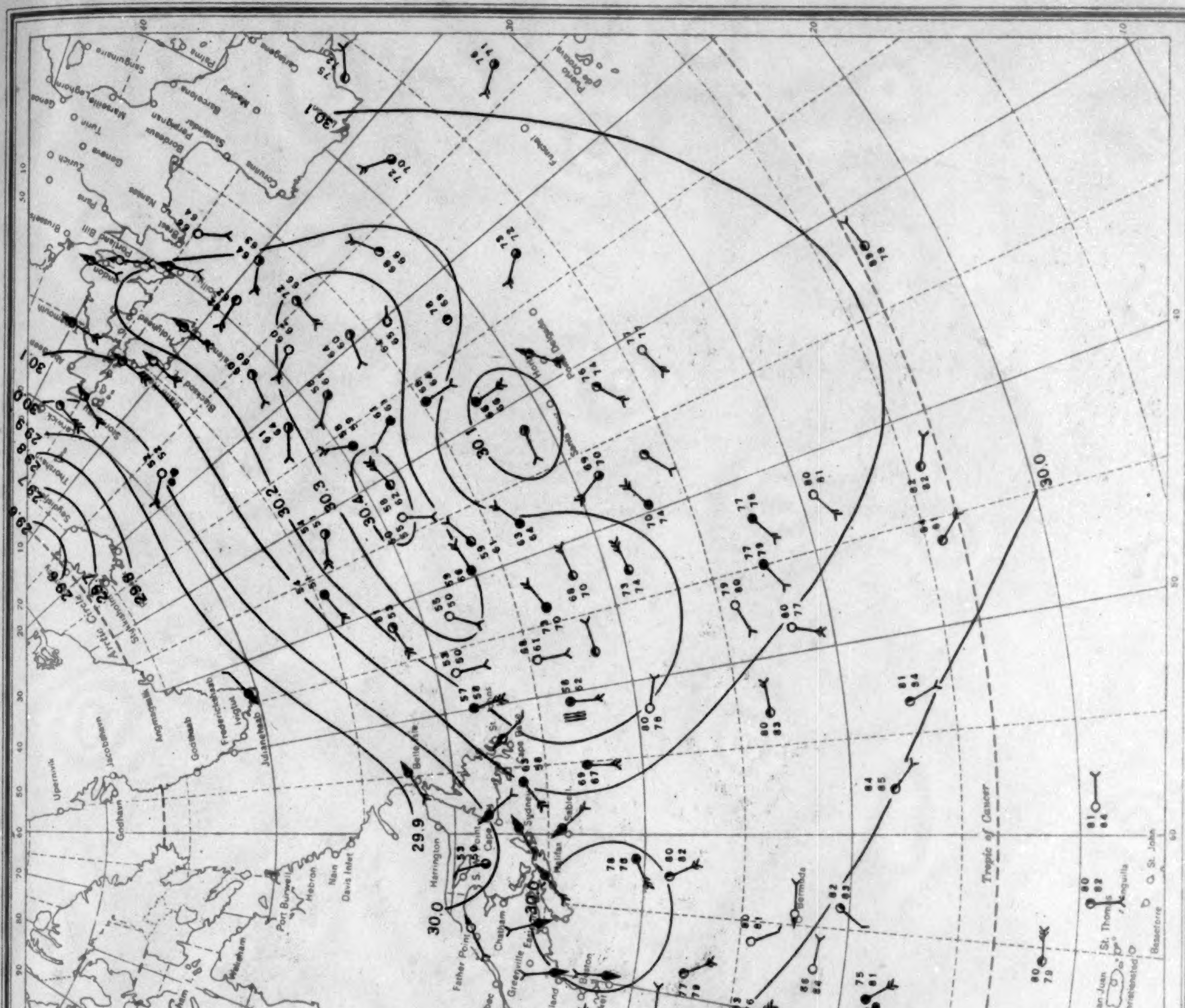


Chart XIV. Weather Map of North Atlantic Ocean, September 18, 1928
(Plotted by F. A. Young)



Greenwich Mean Noon.
Isobars show corrected barometric readings in inches of mercury.
Arrows fly with the wind.
Number of feathers indicate force, Beaufort scale.
Weather symbols are as follows: ○ clear, ◐ partly cloudy, ● cloudy, ⁏ rain, ▲ hail or sleet, ✱ snow, ≡ fog.
Pointed arrows indicate land stations.
Pairs of numbers indicate temperatures of air and surface of water in Fahrenheit degrees. Upper number, air; lower, water.

Chart XV. Weather Map of North Atlantic Ocean, September 19, 1928

(Plotted by F. A. Young)